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A Study of the Field Requirements of Garden Tractors - - - - - - - - - - - - - *A. A. Stone*

Results of Some Garden Tractor Observations in Michigan - - - - - - - - - - - *E. C. Sauve'*

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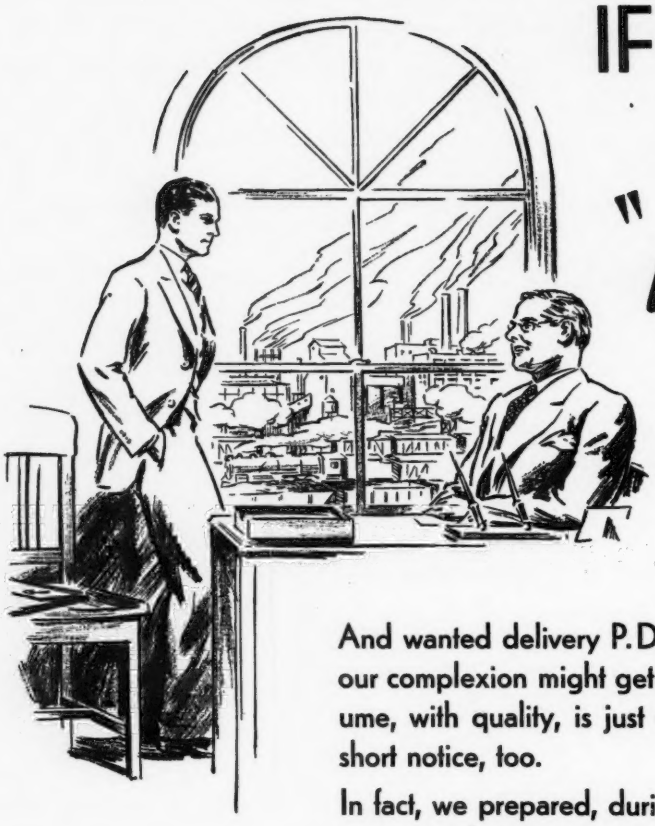

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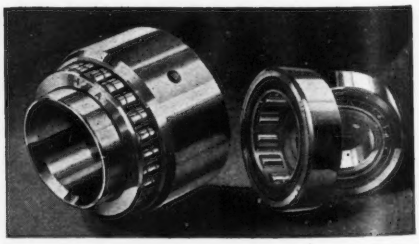


HYATT

ROLLER BEARINGS

PRODUCT OF GENERAL MOTORS

Field Requirements of Garden Tractors[1]

By A. A. Stone[2]

THIS PAPER may be considered as a message from users and potential users of garden tractors, for it was prepared from information obtained by visiting such people, by sending questionnaires and letters to leaders in several branches of agriculture, by making field tests of garden tractors at the N. Y. State Institute of Applied Agriculture, and by a general study of the subject.

Who uses garden tractors, or who may be considered potential users of these machines?

1 *Truck Farmers.* There are 84,000 specialized truck farms in the United States, the average size of which is 60 acres. Nearly 3 million acres of vegetables were harvested for sale in 1929, an increase in acreage of 97.4 per cent in 10 years. The acreage increase in many vegetable crops since 1919 is phenomenal, as is shown by the following:

Acreage increase of spinach	1919 to 1929—	479%
Acreage increase of beans (snap or string)	1919 to 1929—	207%
Acreage increase of cauliflower	1919 to 1929—	210%
Acreage increase of green onions	1919 to 1929—	1,000%+
Acreage increase of lettuce	1919 to 1929—	433%
Acreage increase of carrots	1919 to 1929—	229%

Improved methods of refrigeration and faster transportation make possible the sale of fresh vegetables anywhere in the United States at any season of the year. This apparent change in our eating habits may be in part the cause of surpluses in other commodities. Certainly the rapid increase in the vegetable acreage will place the truck farmer first in our list of users of garden tractors.

2 *Nurserymen and Florists.* There were 29,946 of them in the United States in 1930, and their products are valued at $145,702,666 annually.

3 *Institution Farms and Country Estates.* There are 5,806 in the United States. These are public or semi-public institutions or private estates but in all cases the number of individuals living on the premises is large, sometimes many thousands. Thus the need of a large vegetable production is evident.

4 *Boarding and Lodging Farms.* There are 6,201 in the United States. Conditions are quite similar to No. 3.

5 *Self-Sufficing Farms.* There are 489,019, where nearly all the products are consumed on the farm, indicating a large proportion of row crops.

6 *Part-Time Farms.* There are 339,207, where the owner-operator is away more than 150 days per year. Under such conditions keeping horses is inconvenient; mechanical power should be advantageous.

7 *Producers of Small Fruits and Berries.* In 1930, there were 622,487 who reported the production of such crops.

8 Farms where garden tractors might be profitably employed for special operations or as an auxiliary to other forms of power; for example, many poultry men are interested in or own garden tractors.

Or we might get a picture of the potential market from a study of the number of small farms, farms where a garden tractor might be capable of furnishing the power needed. In the United States there are 38,263 farms under 3 acres in size, 283,535 farms from 3 to 9 acres in size, and 515,017 farms from 10 to 19 acres in size.

I know that some people in all of these classifications are interested in garden tractors, for I have received letters and inquiries from individuals in each class. No matter how we interpret or modify these figures the numbers are impressive. To me they indicate a large potential market, waiting for more favorable economic conditions or perhaps for better and cheaper tractors. Certainly the possibilities are great enough to justify the continued effort of designers and manufacturers.

* * *

What must a garden tractor be able to do to meet the requirements of the truck farmers? Remember that the average size of the specialized truck farm is 60 acres. It is not a "backyard" proposition, but a comparatively large investment, usually on high-priced land. The truck farmer wants a garden tractor for *one* reason — for cultivating his row crops, especially his narrow-row crops. He has other means of plowing, for he usually owns a farm tractor or horses. He wants a garden tractor that will do as accurate and as close cultivating as a man will do with a hand wheel hoe, and do it faster and more economically. Also he wants to be able to set the machine for wide row crops and to cultivate more deeply. The tractor must have ample reserve power. The truck farmer raises a large variety of crops which require different treatment in respect to row widths, number of cultivations necessary, depth of cultiva-

[1]Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, at Chicago, December 1933.

[2]Professor of farm mechanics, New York State Institute of Applied Agriculture. Mem. A.S.A.E.

tion, etc. Some crops must be hilled up and others planted on ridges to be built up by the tractor. Garden tractors for the truck farmer must be adequately equipped with tools which are easily interchanged and spaced. The tractor may be required to operate garden seeders, sprayers, fertilizer distributors, etc.

Table I gives the cultivating requirements of vegetables commonly grown on Long Island. With these facts in mind we may then attempt a rough statement of the specifications of a garden tractor for the truck farmer as follows:

1 *Engine of Sufficient Power for Early Cultivation of Wide-Row Crops.* This means an engine of at least 3 to 5 bhp. This should give adequate power for this operation, as well as for multiple-row cultivation of narrow-row crops. There is much evidence to prove that present models are underpowered. The engine should have a specially designed air cleaner. Garden tractors come in closer contact with the plant foliage than do farm tractors. Under this condition there is the probability of leaves and trash being drawn into the intake pipe, restricting it, probably hastening carbon formation, and making it difficult to get a good carburetor setting.

The engine should have a variable-speed governor so that it may be idled down without restricting the power, and also permit the operator to give more of his time and attention to controlling the cultivator, without the need for constantly manipulating a hand-operated throttle. There is not time here to go further into engine design. To do so would take all our available time.

2 *Variable Tread for Tractor Driving Members.* This calls for provision for adapting the machines to row widths of from 12 to 30 in.

Where two driving members are used, a variable tread seems essential. The single drivewheel, or track, gives some advantages in this respect. To set such a machine for wide rows simply means changing the position of the cultivating teeth or adding more of them. Likewise a single drivewheel machine is easily adapted to multiple-row work. Vertical clearance presents no problem as it does on other types, for the driver runs between the rows. However, some reports I have received on single drivewheel machines indicate that they do not have sufficient traction. An implement dealer on Long Island, with much experience in the design of farm implements, has recently built a garden tractor having a single driving track, 3 in in width. The engine is mounted within the track, and the track passes over the top of the engine. This design is readily adaptable to narrow-row, wide-row, and multiple-row cultivation. It can be set to cultivate any number of rows for which its engine power is adequate. This single-driving track has a ground contact of about 87 sq in, which should give good traction.

3 *Strong, Well-Designed Cultivator.* It should be adjustable in width, with provision for *securely* attaching and positioning a wide variety of shovels, teeth, disks, hilling plows, etc.

4 *Cultivator Carriage and Depth Control.* Lifting the cultivator teeth for turning at the ends of rows, for transport, and for adjustment for depth of cultivation, are factors that should be considered in the design of the cultivator carriage. A carriage can be designed that would combine all these features. It would of course need to be adjustable in width. With one lever placed in an easily accessible position it should be possible to regulate depth and lift tools from the ground for turning or for transport. This construction might be somewhat similar to that used on tractor plows, where lifting, lowering and depth adjustment are all controlled by cranking the axles backward or forward as desired. Such a construction would eliminate the need for manual adjustment by setscrews, as is the case on many models at present. It would make it unnecessary for the operator to carry any of the weight of the cultivating unit. At present, when soft spots in the field are encountered, the operator must carry the cultivator to prevent stalling of the engine. With one quick-acting depth lever he could overcome this difficulty.

5 *Positive, Quick-Acting Cultivator Control for Dodging Plants.* Where two driving members are used, a combination control must be used if the cultivator is carried at the rear of the tractor. By this I mean that the connection between the cultivator and tractor must be pivotal and must so act that, when the tractor is swerved to the right to avoid plants, the cultivator also moves toward the right. If the tools are rigidly mounted at the rear of the tractor, dodging is very difficult, as steering the tractor to the right swerves the cultivator to the left, thus bringing the cultivator teeth closer to the plants we are trying to avoid.

If the cultivator is carried in front, a more nearly rigid connection is feasible as the cultivator teeth will then move in the same direction as the tractor is steered. It seems possible that front mounting has many desirable features, if it can be designed to give the operator clear vision of the work.

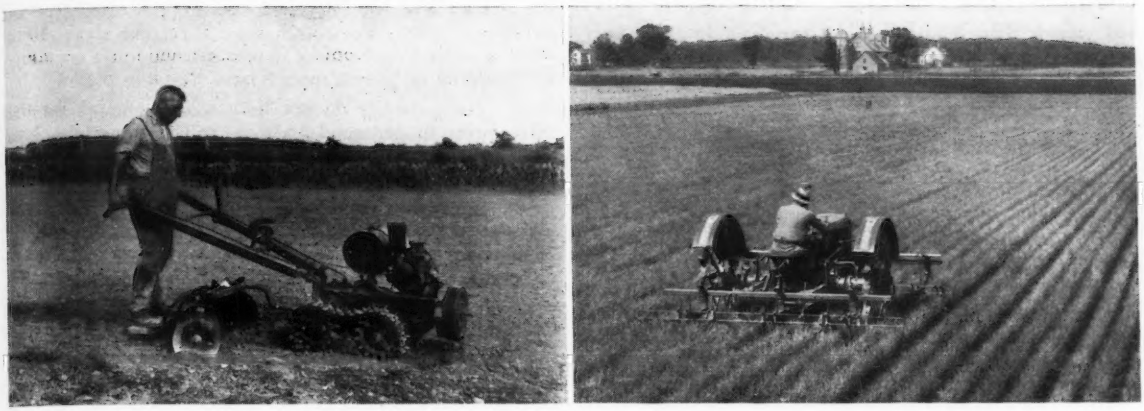
Designers, who choose rear mounting of the cultivator, might profit by studying the parallel beam shift construction commonly used in horse-drawn riding cultivators.

TABLE I. ROW WIDTHS AND CULTIVATING REQUIREMENTS OF VEGETABLE CROPS GROWN ON LONG ISLAND (NEW YORK)*

Vegetables commonly grown on Long Island	Average width between rows		Average no. of cultivations required	Average depth of cultivation, in	
	Hand or wheel hoe	Horse		Early	Late
Beans (bush, snap)	16—18	28—36	6	2	1
Beets	12—15	24—30	5	2	1
Brussel sprouts		30—36	6	3	1
Cabbage		28—36	6	3	1
Carrots	12—15	24—30	5	2	1
Cauliflower		28—36	6	3	1
Celeriac (knob celery)		24—30	8	2	1
Celery		24—36	10	2	1
Corn (sweet)		30—36	5	3	1
Cucumber		60—72	6	3	1
Eggplant		48	7	3	1
Kale		30—36	6	2	1
Lettuce	15—18	24—30	7	2	1
Leeks	12—18	24—30	10	2	1
Onions (green bunch)	12—15	24—30	12	2	1
Parsley	12—18		6	2	1
Parsnips	15—18	24—30	8	3	1
Peas (green)	18	24—36	4	2	1
Peppers		30—36	6	3	1
Pumpkins		48—60	6	3	1
Radishes	12—14		4	2	1
Rhubarb		48	6	3	1
Spinach	12—18		4	2	1
Squash		48—60	6	3	1
Tomato		48	6	3	1
Turnips	12—18	28—30	6	2	1

NOTE: Since the principal purpose or function of cultivation is weed control, it follows that cultivation should be done at the time most favorable for killing weeds which is just as they are breaking through the surface. The number of cultivations then will vary with the number and character of weeds, seeds present, the type of soil, the frequency and amount of rainfall, etc. Practically all the benefits derived from cultivation are secured from shallow cultivation. Deep cultivation, if practiced, should be carried on during the early stages of growth and the depth lessened as the plants grow larger and the roots increase in length.

*Table prepared by Wm. V. Cutler, instructor in vegetable gardening, N. Y. State Institute of Applied Agriculture.



(LEFT) A DOUBLE TRACK TYPE GARDEN TRACTOR. (RIGHT) ADAPTATION OF A CASE GENERAL-PURPOSE TRACTOR TO TRUCK AND MARKET GARDEN WORK; IN THIS PICTURE TEN ROWS OF ONIONS ARE BEING CULTIVATED AT ONE TIME

6 *Ample Vertical Clearance.* Where both the tractor and the cultivating unit work astraddle the row, ample vertical clearance must be provided. Adjustments making possible a vertical clearance of 16 in and 10 in in width should be provided for straddle-row cultivation. Greater clearance may be needed for some crops.

7 *Provision for Attaching Seeders, Dusters, Fertilizer Distributors, etc.,* in single or multiple-row units.

8 *Adequate Vine Turners or Plant Shields* to prevent injury to plants.

9 *Differential Type of Drive and Free-Wheeling.* This is important where two drivers are used (a) to facilitate turning at the ends, and (b) to facilitate moving about when in storage.

10 *Good Traction.* One of the complaints often heard is that the present models do not have good traction; that the drivewheels slip or dig themselves in. It may be questionable whether this is due to inefficient lugs or lack of weight on the drivers. This trouble occurs frequently and indicates the need for further study of lugs and drivewheels and for experiments with pneumatic tires.

11 *Power Take-Off.* For use with field mowers, dusters, etc., this may be furnished upon request as special equipment.

The foregoing requirements indicate briefly some of the characteristics a garden tractor must possess to fill the needs of the truck farmer. Perhaps it could be expressed more simply by saying that the truck farmer wants a machine small and light enough to replace the hand wheel hoe, yet strong and heavy enough to do the work of one horse in cultivating his wide row crops. We have discussed a machine designed primarily for cultivating. It is quite right to do so. Cultivating is the most important operation performed by garden tractors, not only when in the hands of the truck farmer, but with all other classes of owners. The success of these machines is dependent upon their ability to do good cultivating.

None of the foregoing requirements are especially new. Some models possess many of the characteristics mentioned. But all of these requirements are real and are gathered from the actual field experiences of many users. Any one of the above points could well occupy the whole period of this discussion, especially that part relating to the design of the cultivator and its control and adjustment. In some designs it seems that the cultivator was an afterthought, with levers, if any, placed in positions of greatest inaccessibility and with an overabundance of setscrews.

The foregoing description answers fairly well the requirements in specialized undertakings other than truck farming, if cultivating is the main objective. Some complications arise in certain crops such as are produced by nurserymen and florists. Such plants or shrubs grow high, too high for straddle-row cultivation. They grow wide near the ground and taper in at the top. With most vegetables the opposite is true; the original width between rows is maintained at the ground level with foliage spreading out toward the top of the plant. Between-row cultivation is the most common with nurserymen and florists. In our territory they seem to prefer machines with a single drivewheel. One large nurseryman reports that the distance between rows at the ground level is as little as 12 in.

The larger the acreage and investment of the individual farmer, the less the probability of his using the garden tractor for plowing. He will have other and better means of plowing. Cultivating narrow-row crops with the present makes of garden tractors has been fairly successful. I have considerable evidence to substantiate this statement. A letter from Mr. A. C. Thompson, production manager of the King Farms Co., the largest, specialized growers of vegetables in the East (1200 acres), states that he considers them practical and successful and great labor savers over the hand-propelled wheel hoe. He states, "On the average a man can cultivate with a hand wheel hoe about one acre per day of crops planted in 12-in and 14-in rows. A small garden tractor under favorable conditions can cultivate from 3 to 5 acres in the same time doing three rows at a time."

There is, however, evidence to show that some of these smaller row-crop cultivators are underpowered.

One of the chief objectives of designers should be to improve these cultivating models. An efficient machine of this type will fill the needs of more than half the potential market, and it will answer the requirements of specialists in production of row crops, men who do not want to use this little power unit for plowing but almost entirely for cultivating.

Now let us consider the owners of small acreages. It is an anomaly that the smaller the acreage the greater the need for a larger garden tractor, a general-purpose type—in brief, one that can do good plowing as well as cultivating. Many owners of small acreages use garden tractors for plowing and seedbed preparation. They do not have land enough to justify the purchase of a farm tractor. Horses are expensive and inconvenient to keep. They raise no feed and have no cheap pasture land. It is often difficult and unsatisfactory to hire their plowing down.

Despite their few acres, they wish to plow as deeply and prepare their land as well as any other farmer. They want to turn under cover crops also. My reports show requirements to be from 6 to 8 in for depth of plowing. They do not demand fast plowing. They would be satisfied with a rate of 1 to 2 acres per day. When plowing is completed and the land harrowed and planted, then cultivating is again the chief operation. But all of these operations may be required of the garden tractor. These owners have no other power for their field work.

It seems logical to discuss this part of the subject as a separate problem. It is quite possible that more manufacturers will find it desirable to produce two models,—one designed primarily for row crop cultivation and one for general-purpose work. Some do this at present. Designing a general-purpose garden tractor is the more difficult job; it is heavier, more powerful, and more expensive.

A few of the more important requirements that a general-purpose garden tractor must fulfill are as follows:

1 It must possess the capabilities of the cultivating model previously described.

2 Capable of plowing at a depth of from 6 to 8 in at a rate of about 1½ acres per day, and be equipped with a plow specially designed for garden tractors.

3 Two forward speeds and one reverse speed.

4 Must possess lateral stability sufficient to prevent tipping, side slipping, and unequal driving, when plowing with one drivewheel in the open furrow.

5 Equipped with power take-off and belt pulley (optional).

6 Provide for attaching 30-in lawn mower (preferably a power-driven mower through a power take-off).

7 Easy change from one implement to another.

8 Good traction, eliminating spinning and digging in of drivers.

Some Constructive Criticisms of Present-Day Designs of Garden Tractors

It seems necessary to discuss at this point some of the present designs. Criticism, especially destructive criticism, is very easy to make. I do not relish a tearing-down process. Many men have labored long and hard to bring garden tractors to their present state of development. Surely these men who have thus far persevered in their difficult problem, are the kind who welcome other viewpoints. They have no pet theories or prejudices that blind them to suggestions from the outside. My interest in this development is sincere. I believe the attempt to mechanize production on small farms is even more feasible than on the large prairie sections where animal power can be more easily and cheaply maintained. My files contain letters from individuals in every state who are interested in garden tractors. My suggestions and opinions are presented with the hope that they may be helpful in a building up and not in a tearing down process.

In general, plowing with garden tractors has not been successful, at least it is not considered so in my section. In brief, it is not successful because we cannot plow deeply enough or get a good straight furrow. We do not get good covering. Operating the machine, when plowing, is too hard work.

1 We have not been able to plow deep enough, because the machines do not have power enough to handle a plow of proper size. To do the best work and cover surface growth well, it is generally conceded that the furrow must be somewhere near twice as wide as it is deep. We can modify this rule somewhat, but as our depth requirements are at least 6 in, we can say that, with the usual type of moldboard plow, we would need a furrow about 10 in wide in order to get proper depth, inversion and covering. The majority of present models have 7 or 8-in plows.

2 Many models do not have weight enough on the drivewheels to get good traction, and in some the lugs are of obsolete pattern. They slip and weave about making it difficult to plow a good furrow.

3 When plowing with one wheel in the furrow, the tractor slides sidewards, making steering difficult and it is liable to tip over.

4 The operator has only indirect control of the plow in most models. He controls it by steering the tractor and the plow has no control inherent within itself, such as is the case with wheeled plows used with farm tractors.

5 In many models necessary and convenient plow adjustments are not provided.

6 With many garden tractors plowing demands a great deal of exertion on the part of the operator due (a) to lack of or inefficient plow-lifting devices, (b) to no reserse speed, (c) to no governor, and (d) to some having no differential, which makes turning around at the ends of the field a laborious process.

Consideration of Factors Involved in Plowing with Garden Tractors

The plow, as we all know, is a complex tool involving intricate hitching problems. It is not always possible to get the center of power and the center of resistance or load to fall in the same line, as the tractor must run at a definite position with relation to the plowing, either on the land or with one wheel in the furrow. Sidedraft usually exists, the effect of which may have to be overcome by the steering of the tractor. With wheel plows such as commonly used with farm tractors, much of the effect of the sidedraft is resisted by various parts of the plow, such as the landside and the wheels. The hitch between the tractor and plow is long, which also minimizes the effect on the tractor.

With nearly all garden tractors the situation is quite different. The plows used are essentially the same as a walking plow, no wheels to support it or to aid in carrying the sidedraft. The weight is largely carried on the under side of the plow bottom. In some cases gage wheels are used, but these usually attach to the tractor and not to the plow. The plow is drawn from the rear, or in some cases from the front of the tractor with a pivotal connection, and a single brace connects to the handle bars of the tractor. The operator controls the work of the plow only by steering the tractor.

We might compare this arrangement to a man plowing with a team of horses and a walking plow, from which the handles had been removed. With a good team, a perfect hitch, ideal soil conditions, and plenty of good fortune he might plow a good furrow across the field. But I never knew a plow manufacturer to try to economize by eliminating the handles of the walking plow.

I am not advocating handles on the garden tractor plow, but I do believe its work would be improved if a rolling landside were added at the rear of the plow; the gage wheel could be changed to a small plow land wheel, and a front furrow wheel may be desirable. It must resist within itself more of the sudden varying loads that are placed on it by irregularities in the soil, and not simply transmit these to the tractor where the operator must fight them in his steering. The addition of wheels would also make possible better provision for raising the plow, adjusting its depth and leveling it, all of which are needed.

Likewise, because of the light weight of the tractor, and its tendency to slip and weave, the set of the plow and the angle at which it meets the soil is constantly changing. The width and depth of the furrow is affected, making it difficult to plow a straight furrow. This could in large measure be eliminated if the plow had more stability of its own and was connected to the tractor at a single point, and the hitch at this point should be pivotal both vertically and laterally.

More study and improvement in the garden tractor plow is needed. A closer resemblance between it and the standard plows used with farm tractors would be desirable. This need not make the total outfit longer or more cumbersome, because the point of hitch between the plow and tractor could still be at the front of the tractor, as it is now in many cases.

To illustrate some of the foregoing statements, the following is a brief summary of some actual field tests of plowing with garden tractors made this fall (1933) at the State Institute of Applied Agriculture at Farmingdale, N. Y. Their purpose was to determine the quality of plowing and the ease or convenience of operation of each machine. Such tests, of course, are rather crude; the various factors involved are not accurately measurable with instruments, but are the opinions and judgments of the individuals in charge. At least they were tests under actual field conditions and therefore apply to this discussion.

Three tractors were tried under the same conditions, plowing in a field recently seeded to wheat, which had grown to a height of about 3 in. The soil contained plenty of moisture, quite level, no rocks or stones, and no trash on the field. Sandy loam soil which would probably have a resistance of 4 to 5 lb per square inch. Sufficient time was spent with each outfit to get the best adjustments possible to us.

Tractor No. 1. 2-hp, air-cooled, single-cylinder engine; tractor had two drivewheels; land drivewheel, 3-in rim; furrow drivewheel doubled, or two 3-in rims; pawl-and-ratchet type of drive, giving free wheeling and differential action; 7-in plow with rolling coulter; plow connected ahead of the drivewheels; no plow wheels or gage wheels of any kind; distance between theoretical center of resistance and center of power, 1¾ in; no reverse and one forward speed.

Some of the Difficulties Encountered in the Use of a Particular Type of Garden Tractor

Results: Good, well-turned furrow and keen furrow wall and bottom, but all in a miniature way. Depth would average 4½ in; greater depth caused overload and stalling. The following difficulties were encountered:

1 At times the operator must carry considerable weight on the handles, when soft spots in field were encountered, to prevent the tractor from stalling.

2 The operator must lift the plow from the ground when turning and carry it around the ends.

3 The plow had a tendency to wing over on to the share, making it hard to keep the landside plumb and maintain proper width.

4 Excessive vibration; gas lines worked loose and leaked.

5 Depth not considered sufficient for seedbed preparation under our conditions.

6 Tendency to tip when the drivewheel is in furrow, or when the field is uneven.

Tractor No. 2. 4-hp, air-cooled, single-cylinder engine; two drivewheels driven by rigid axle with driving lug on each end of axle and driven lug in each wheel, giving a semi-differential action and semi-free-wheeling; land drivewheel 18 in in diameter and 6 in rim; furrow drivewheel 24 in in diameter and 4-in rim (This construction is intended to keep tractor level when plowing with one wheel in the furrow); 8-in plow rigidly attached to carriage at the rear of the tractor—two wheels on rear carriage, one running in furrow and the other on land; lever for lifting and lowering the plow; rolling coulter; distance between center of power and center of load, ¾ in.

Results: Depth (average) 5 in to 5½ in. The following difficulties were encountered:

1 Difficult steering due, we think, to uneven action of the two drivewheels, causing side swerving and resulting in a crooked furrow and hard turning at the ends (poor differential action).

2 Lifting lever difficult to operate.

3 Carburetor, if set rich enough for load, would smoke excessively when idling.

4 Clutch trouble occurred; design of clutch does not permit gradual engagement and is difficult of access for repair.

5 Although depth obtained was greater than with Tractor No. 1, it is questionable if this depth, or the depth possible under less favorable conditions, would be sufficient.

Owners of Small Acreages Want a Garden Tractor That Will Plow Deeply

Tractor No. 3. 5-hp, water-cooled, single-cylinder engine; two driving tracks, both running on land; distance between center of resistance and power 4¾ in (with right track 2 in from furrow wall); 10-in plow connected to tractor at a point centrally located beneath the tractor; no rolling coulter; one forward speed and reverse.

Results: Average depth, 6 in—only one of the three that could be considered adequate in this respect. The engine could be idled down considerably and still carry its load. Sidedraft was not noticeable when plowing, as both tracks drive ahead equally. Steering was not difficult when plowing. Turning at the ends was very difficult. Lifting of the plow was difficult; the tractor had to be reversed each time to get the weight of the furrow off the plow. Raising or lowering of the plow disturbed the throttle setting and caused racing or stalling of the engine; it also changed the position of the handle bars to an awkward position. The plow lifting lever mechanism frequently caught on projecting parts and failed to function. Gear shifting was difficult. Plowing was reasonably satisfactory in spite of difficulties and inconvenience. This tractor did the best plowing of any of the three, but it was the most difficult to handle.

Perhaps the foregoing are crude tests and should not be reported without further trials, but they serve to illustrate the conditions that exist at present. All of these machines were current models, but it is only fair to say that improvements in some features have been worked out for the 1934 models.

The operators of these machines were students, all of whom had had some previous experience. Any one of them is capable of doing a very creditable job of plowing with farm tractors. Also they will take the same garden tractors and do a job of cultivating of such quality as to satisfy a rather exacting department of horticulture.

The point is that it is more difficult to operate and control a garden tractor in plowing than a farm tractor. The man is more a part of the machine. Control is more man-

ual and less automatic. Hence the designer's problem is greater. Ease of handling is an important factor and must be obtained.

Progress in the design of general-purpose garden tractors will be made when the engineers realize the fact that owners of small acreages want to plow as deeply as any other farmer.

Then in order to determine the drawbar horsepower needed to get this required depth (6 to 8 in) he must consider the following factors:

1 *Width of Plow* (standard moldboard type). This refers to the width of plow that must be used to get this depth. Many plow men say that a plow does its best work when the width of furrow is twice its depth. This rule is subject to considerable modification, but no doubt the width of plow does limit the depth at which it can work efficiently.

2 *Type of Plow Bottom.* It is possible that a bottom approaching the breaker type could be used satisfactorily; it gives good inversion with light draft, because the amount of pulverization is lessened. This might not be a serious objection even though it made necessary more subsequent operations in preparing the seedbed.

3 *Rate of Plowing.* Here the demands of the users are quite lenient. Replies to questionnaires indicate that a rate between 1 and 2 acres per day would answer the requirements. In fact one man says, "Any rate if I can get deep enough." This indicates the possibility of a low speed for plowing, thus raising the drawbar pull. This of course is the opposite of present trends in farm tractor design where plowing speeds are being increased with good results. But conditions are not the same with the owner of a few acres. His plowing is soon completed and the remainder of the season's work is lighter. We can cut down the forward speed, if it will result in greater depth and still give good inversion.

When the proper horsepower is found and suitable speeds determined, then much effort can be put upon the design and improvement of the plow itself to make it specially fitted for garden tractor use. The following are important plow requirements:

1 It must possess more stability within itself so that it does not affect the steering of the tractor.

2 Connections between plow and tractor must be such that slight slipping or swerving of the tractor does not immediately affect the set of the plow. The addition of a rolling landside, plow wheels and a hitch between tractor and plow that is pivotal both horizontally and vertically may aid in these problems.

3 Better provision for depth adjustments and horizontal or width of furrow adjustments may be possible.

4 Plow-lifting devices or levers should be improved.

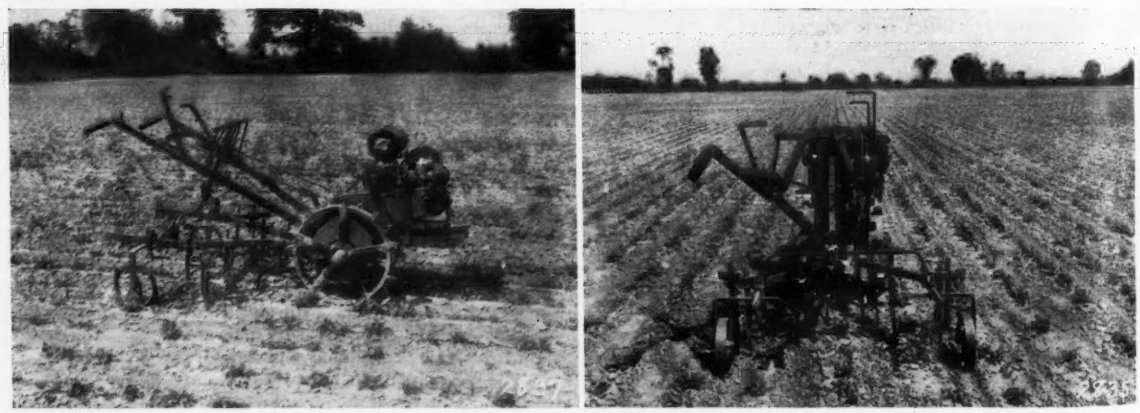
5 A combination coulter and jointer should be furnished as standard equipment.

Then as regards the tractor itself, in order that it may do better plowing. Lateral stability, especially when one driving member is in the furrow, must be improved so that both drivers will drive equally and lessen slipping and sliding sidewards. Perhaps the addition of wheel weights or a combination of wheel weights and low-pressure pneumatic tires would largly eliminate this trouble. Reports from one manufacturer state that it does. In brief, we feel that the main problem on which efforts should be centered is to improve the quality of plowing and ease of handling when plowing. This must be done without too great an increase in horsepower and weight, which would add to the cost and make for less economy in the lighter operations.

I should like to mention very briefly two more factors that must be considered. First, the increasing competition from small general-purpose farm tractors. Lately these have been adapted to truck farm work. To illustrate, let me quote again from Mr. Thompson's letter relating to a popular make of general-purpose farm tractor. He says, "This style of tractor is something we have needed for years. Its size and construction make it capable of displacing an enormous amount of man and horse labor in the growing of vegetables. By means of suitable attachments it will perform delicate jobs of seeding, cultivating, spraying, harvesting, etc., besides having sufficient power to do a thorough, speedy job of plowing, fertilizing, and ground fitting. Vegetable enterprises as small as 5 acres will justify the expense of one of these tractors." Second, the most common reaction to our garden tractor questionnaires is that their price is too high. Prospective purchasers compare these prices to farm tractors and feel that they are out of proportion.

* * *

In this paper I have tried to cover the subject assigned me as thoroughly as the time available for preparation would permit. I am sorry the picture, as I see it, is not all favorable. But these facts remain: (1) There is a large potential market, and (2) the attempt to mechanize production on small acreages is entirely logical, for maintenance of animal power in such situations is not economical. Certainly the ingenuity of American engineers is equal to the task at hand.



TWO VIEWS OF A PLANT JR GARDEN TRACTOR CULTIVATING THREE ROWS OF SPINACH

The Garden Tractor in Michigan[1]

By E. C. Sauve[2]

THE AGRICULTURAL engineering department of Michigan State College has been interested in garden tractor study for about eight years. Queries from potential users required that information be secured in order that those seeking guidance could be helped. Questionnaires sent out to several hundred owners scattered throughout the state made possible the tabulation of rather interesting and useful material, some of which will be presented in this paper.

At the outset it should be known that Michigan presents a diversified type of agriculture on diversified types of soils. The garden tractor that appears to be giving entire satisfaction in muck soils may be found unsatisfactory in clay or sandy soils. It is not unusual to find these three types of soils present in the same field on some of our Michigan farms.

The plan of attack in our garden tractor study was to consult with owners through the medium of personal visits and questionnaires in order that we could learn the various factors affecting the economical use of these small tractors. We were able after analyzing and tabulating the material as obtained in the survey to get a fairly accurate picture of what the truck grower thinks about garden tractors in general.

A garden tractor dealer once said in response to a request for names and addresses of tractor owners that only disgruntled owners will answer a questionnaire. While this opinion may be true to some extent, it did not have much bearing on those received, for 72 per cent reported definitely that they believed their tractor to have effected a saving over other forms of power, and the same percentage stated that their tractors met their power requirements. Further analysis shows that, while the majority expressed general satisfaction in their choice of tractor, they were almost unanimous in offering some criticism. Among these criticisms were such expressions, as "My tractor is too heavy for its engine power," or "My tractor is too cumbersome to handle." It is obvious that reports such as these indicate that the owner did not analyze his power requirements sufficiently.

Selection of Power Unit. The prospective garden tractor owner having first established a need for this type of power should acquaint himself with such information as will qualify him to make the proper selection of his tractor. The following points should be given special consideration:

1 Is the tractor reasonably priced?

2 Is the manufacturer a reputable and going concern?

3 Does the tractor under consideration have too little or too much capacity to meet the power needs?

4 Do the wheels or traction mechanism provide ample traction for the particular soil on which the tractor is to be used?

5 Does the tractor provide ample adjustment of wheel spacing and arch clearance for cultivation requirements?

6 Does the tractor provide for reasonably quick adjustments of cultivator shovels?

7 Are the tractor wearing parts sufficiently protected from dust?

8 Are the tractor controls accessible to the operator?

9 Will the tractor turn at the end of rows with little manual effort?

10 Can the manufacturer provide reasonably quick service on repairs?

The reputable manufacturer will insist that his sales men provide information and equipment to meet the prospective owner's needs.

Michigan dealers are divided into three classes: (1) Those who sell tractors as a side line to another business covering rather small territories; (2) those who sell one make of tractor in a large territory, and (3) those who sell several makes of tractors, large and small, to cover the full requirements of the market gardener.

This last classification appears to have definite advantages as it provides a wider choice on the part of the potential user in making his selection. One such dealer is operating in Michigan and is known throughout Southern Michigan as being reliable and successful in this work. This type of dealer because of large volume sales is in a better position to provide ample servicing and repair facilities which will lead eventually to satisfied owners and repeat busines; for the dealer and manufacturer.

Mechanical vs Horse Power. The records seem to indicate that the horse and tractor argument is not important in market gardening operations. Garden tractors are recognized by their owners as being essentially a cultivating tool and in many instances must operate in narrow-row crops for which the horse is unsuited.

The average area on which garden tractors were used, based on a report of 104 owners, was 18 acres. Seventy-five per cent of this number used their tractors on 10 acres or less. There are a number of garden tractor users in the metropolitan area of Detroit who come under this classification. These small areas ordinarily could not support a horse the year round, and in many cases housing facilities would not permit the maintenance of a horse for market gardening work. It becomes a choice then between manually operated tools or the garden tractor. It may be of interest to know that out of twenty-four owners reporting who have small garden tractors under 1½ hp, three did all of their power work with tractors, including plowing. Twenty out of fifty-two reporting on the intermediate size (from 2 to 5 hp) performed all of the work with tractors and nine out of fifteen reporting on the large size garden tractor (rated from 6 to 10 hp) performed all of the work with the tractor. It is obvious from these figures that although some of these tractors while not especially designed for plowing were used for this purpose. In many instances this was brought about by necessity inasmuch as other forms of power were not readily available for plowing and fitting the fields for crops.

Power Selection for Large Acreages. On large acreages it may be desirable to weigh the advantages and disadvantages of available forms of power. Following is a list of

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[1]Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers held at The Stevens, Chicago, December 1933.

[2]Assistant professor of agricultural engineering, Michigan State College. Assoc. Mem. A.S.A.E.

advantages and disadvantages of tractors and horses as reported by users in market gardening work:

Tractor Advantages—(1) Operation costs are low; (2) small tractor works well in narrow as well as wide row crops; (3) tractor does not eat when not in use; (4) does work quicker and better than with a horse; (5) no care when not working; (6) easily stored when not in use, and (7) quickly made available for work.

Tractor Disadvantages—(1) Small tractors do poor job of plowing; (2) price too high; (3) too cumbersome to handle; (4) poor repair service offered by manufacturer, and (5) not enough traction in sandy soils.

Horse Advantages—(1) Low cost if horse can be used for other work; (2) satisfactory in medium and wide-row crops, and (3) no traction difficulties.

Horse Disadvantages—(1) Horse consumes profits during idle months; (2) tramples crops planted in narrow rows, and (3) horse care in off season objectionable.

Tractor vs Horse Cost. If one were to ask a garden tractor owner how much it costs him to operate his tractor, he will very likely say, "Not very much," and will proceed to give you a cost based on fuel and oil alone. Overhead or fixed costs are little understood by the average user and should be considered as important.

A detailed discussion of how costs are determined will not be attempted here, except to say that the items of depreciation, interest on investment, repairs, taxes, housing, insurance, fuel, oil, and grease are necessary to consider in a cost determination. The tractor and equipment which sell for $100, an extremely low value as tractors are priced, will cost the operator about 18 cents an hour, while the tractor selling for $250 will cost approximately 40 cents an hour. These price figures are based on 150 h use per year and an estimated life of seven years.

Horse costs are likewise variable, and it becomes difficult to make direct comparisons with tractor costs. Where a horse is used efficiently in general farming work, it is believed that 10 cents an hour would cover this charge. However, the cost of keeping a horse whose work was confined solely to market gardening operation would be considerably in excess of this amount.

Remarks of Owners. The following comments of garden tractor owners are interesting:

"The agent would have done me a great favor if he had said the tractor would plow, but that it would be much better to hire the plowing done. It is a real pleasure to work with our tractor."

"You can stop work at any time with a tractor. It will not run away or trample the rows. I have trouble in cultivating spreading plants. Wheels cut the vines."

"My tractor is not too light to plow, still light enough to cultivate."

"My tractor will cultivate anything in the garden or field. Does not use over 2 gal of gasoline a day."

"The high wheels of my tractor prevent bruising and breaking of plants."

"My garden tractor is just the most wonderful piece of machinery for every one, especially for women who do not wish to handle a horse."

"My tractor is too light for the nature of the soil, as it is sodded and very heavy clay. When the sod is turned under, the top soil is soft and tractions become difficult. It is not heavy enough."

"My tractor does not weigh enough for a good plowing job."

Engineers Aid Farmers in Cutting Crop Costs

COTTON PLANTED with the new variable-depth planter developed by engineers of the U.S.D.A. Bureau of Agricultural Engineering produced 14 per cent more cotton than the highest yield from any other method of planting in tests at Prattsville, Ala., last year. This is one of the practical examples of the service of engineering to agriculture which is recorded in the recent annual report of the Bureau. Planting with the variable-depth planter makes more certain a good stand whatever the weather that follows.

Engineers are developing corn-picking machinery that will cut stalks at the ground level and will then cut them into small pieces, destroying or exposing any European corn borers in the stalks. Another aid in fighting the corn borer is a conical device which may be attached to plows to aid in covering weeds, stalks, and trash. A public service patent has been granted on this invention.

In a western sugar beet area about 35 per cent of the growers were able to get through the season without the usual need for importing low-grade labor for blocking beets. Machines did the work better and cheaper.

At least 45,000 bales of cotton were dried and conditioned in long-staple areas by ginning plants that adopted the seed-cotton drier which Bureau engineers developed recently and which they further improved last year.

The report points out that "the unfavorable situation with regard to prices of agricultural products has served to emphasize the necessity for reducing the cost of farm production," and indicates ways in which the program of the Bureau has helped farmers to meet current problems.

When the federal emergency conservation program was put forward, it depended in many ways on recent research by the agricultural engineers. The bureau is assisting the Forest Service in supervising flood control work by the CCC. Years of field work in the construction of soil-saving dams and in control of gullies enabled the engineers to outline a sound program for this kind of work. The report gives details of how experiments in terracing and other methods for control of soil erosion have contributed to real conservation of this basic resource of agriculture.

Irrigation and drainage research has always been a principal activity of the Bureau. Last year it completed the last of five studies dealing with the irrigation requirements of the five major regions of the West. Studies in the most economical application of irrigation water are continuing. Deep irrigation is rarely essential, engineers find. For many plants and trees irrigation of the top three feet will also moisten the next three feet, and few crops need draw water from deeper than six feet.

A plan for rehabilitation of one of the largest drainage districts in financial difficulties was worked out by the engineers. This provides that each year the annual drainage tax levies shall be based on crop yields and farm prices received in the districts, and that after operation and maintenance expenses have been deducted, the remainder will be accepted by bondholders in full for the obligations maturing in the year.

The Greater Efficiency of Rotary Tillage[1]

By C. W. Kelsey[2]

IN ANOTHER PAPER Prof. A. A. Stone has so graphically described the standard type of garden tractor and brought out so clearly the point that all of these machines incorporate, to a considerable degree, qualities similar to the dragging of an anchor, that he has in this way very kindly led up to my subject of rotary tilling which, as you all probably realize, is a fundamentally different method of soil tillage, quite the reverse of dragging an anchor. Accordingly I shall endeavor to explain the basic principles of rotary tilling as originally conceived and its development up to the present time.

Rotary tilling is an old idea. Its original inception probably goes back a hundred years. Since this time many patents have been taken out covering the rotary idea. Broadly speaking, all of these early patents dealt with the idea of revolving a long solid cutting edge similar to the edge of a hoe at relatively high speed—this cutting edge operating much as a milling cutter works in a machine shop, only substituting soil for the material to be cut up.

Considering this type of rotary tilling, it will quickly be seen why this method has never been successful and possibly never will be developed into a satisfactory machine.

Let us consider for a moment a wheel constructed somewhat like a paddle wheel on a boat, but so arranged that the edges of the paddles are long, heavy, hoe-like cutting tools coming down on the ground with a shearing, ax-like action. If the ground is hard or contains trash or obstructions or stones, you will readily see what a terrific blow is imparted not only to the long edge which comes in contact with the ground, but through this edge on to the wheel construction, and through this to the entire mechanism. In order to make a machine sufficiently strong to withstand this terrific beating, you will readily realize how heavy these parts would have to be built. As a result, enormously heavy tools are involved. This is the primary fault with all of the early designs of rotary tilling machines.

This difficulty was, of course, quickly realized by each inventor as he built his machine and put it into practical operation. Finding this fault, their way out seemed to them to be in mounting the milling or cutting wheel so as to slip under extra load, or mounting each separate long cutting edge in such a way as to relieve this shock through some spring arrangement.

None of these devices ever worked out to practical and economic success. All that was in a practical way achieved by the additions of these devices was a heavier and more clumsy machine—more expensive to make and always a tremendous power consumer.

It is interesting to note in the description of the patent of one of these early machines that "tilling" is referred to as "plowing" and no suggestion is made as to the words "rotary tilling," or as to the function that the tilling action also exerts tractive effort. When looked at in the light of present-day knowledge, this machine looks very crude and cumbersome.

An entirely different type of rotary plow, or rotary tilling device was designed primarily as an attachment to be used in conjunction with the standard type of tractor taking its power from the power take-off. This and the first machines described show that the designers of these heavy type machines were not considering of great importance the thought of using the digging action also as a propelling action.

This is a vital point because the efficiency of the modern rotary plow to a large extent achieves its extraordinary efficiency because its digging action is also used largely as its propelling action, and there is no dragging-an-anchor effect, as incorporated in conventional plowing methods, as shown by Prof. Stone.

The tractor wheels on rotary tillers are used as much to hold the tractor back as for propulsion. If these wheels were on free spindles, you can readily see that should the fast revolving cutting tools hit hard ground the tendency would be to propel the entire machine forward at a high rate of speed.

In 1910 a Dr. Von Meyenberg of Zurich, Switzerland, made application for an American patent on what was at that time a completely new idea in tilling. This new idea is probably more clearly described in Dr. Von Meyenberg's first patent application than I could describe it, so I quote from his patent as follows:

> Many forms of rotary apparatus for mechanical tillage have been devised recently. Most of them consist of a drum hung out backwardly from a wagon and fitted with suitable knives, having its axle horizontally disposed and rotated by a motor located on said wagon. Most of them rotate forwardly like the wagon wheels, in order to require no pull from the wagon. Most of them have these knives rigidly disposed.
>
> The present invention is intermediate of these two systems, as it uses neither the falling action nor the positive mechanical push of these tools, but the well-known scraping action of independently dragged elastic claws, like those of the spring-tine cultivators. Its purpose is to scrape off the compact earth clods or grains of the right size required by the seed and plant for good growing. This requires a very great number of little cuts and, therefore, a multitude of narrowly spaced edge tools which, if rigidly fixed to a rotating shaft, would require an enormous amount of power.
>
> The power of earth cutting by edge tools depending mainly upon the sharpness, section, and surface of the tools and of their "free cutting," I make them of small section and surface, preferably self-sharpening, elastic, and independent, so that each edge, also rotated mainly in a circle, may give way laterally and backwardly, like the claws of a scraping animal, and follow the way of least resistance upon a trembling or shivery curve.
>
> Earth being scarcely elastic, any shock of a tool means a loss in energy. I prefer therefore to make the tools not only elastic but also of small mass, in order to be able to use high speed.
>
> I prefer claws formed simply of steel wire and bent forwardly like cultivator tines and thereby being always sharp in spite of their being used up, and conveniently bent and fixed on elastic arms, slightly inclined backwardly, to obtain that animal-like elastic dragging by pulling a stitching tool exactly like the plow is pulled and not pushed. I prefer to allow the claws to give way much more backwardly and inwardly than laterally, so that each one may follow its line in the earth, but be able not only to give way inwardly a fraction of an inch, but so much that it may avoid big stones and roots occurring sometimes. But I prefer to make use of this freedom only in rare cases of great, obstinate obstacles, before the resistance becomes so great as to be a danger for my sharp claws.

This idea of revolving small self-sharpening points like ice picks flexibly mounted on springs at comparatively high speed—revolving these points in such a way that not more than one point on either side of the center drive of the propelling shaft would come in contact with the ground at the same time, and so arranged that the cutting action

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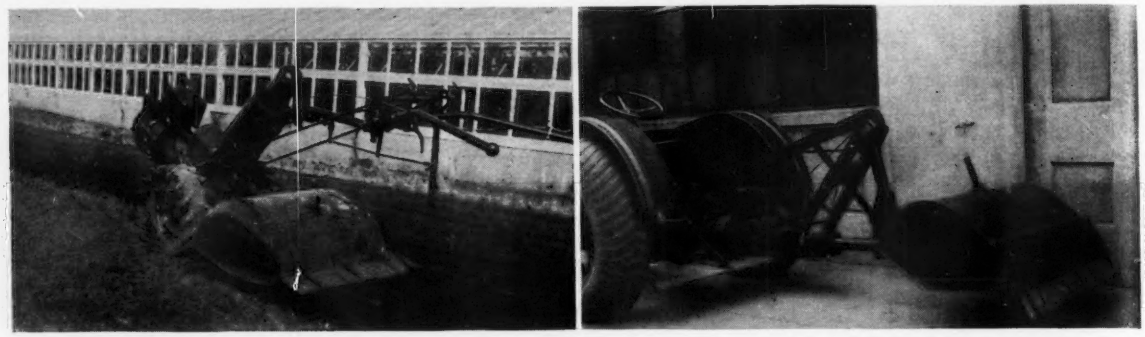
[1]Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, at Chicago, December 1933.

[2]President, Rototiller, Inc. Mem. A.S.A.E.



(LEFT) A ROTOTILLER DOING A GOOD JOB OF PUTTING UNDER CONSIDERABLE TRASH AND MAKING A GOOD SEEDBED. (RIGHT) THE LATEST DESIGN OF ROTOTILLER ATTACHMENT FOR A TRACTOR. CAPACITY, ½ TO 1½ ACRES PER HOUR

would, at the same time, help to propel the whole machine forward—was an entirely new principle.

In the Von Meyenberg design each small cutting tool rapidly revolving can only dig up a very small amount of ground and consequently the amount of power consumed by each tool is small as compared to the long, heavy, straight cutting edges incorporated in the earlier inventions.

Accordingly the result in shock to the mechanism is tremendously reduced, and this permits the construction of very light efficient machines which waste little power in the propulsion of the machine itself.

In other words, the lighter the machine can be constructed, the less horsepower will be used for propulsion of the machine itself, and the more efficient the machine becomes. This, you will readily realize, is a most important advance step, as up to this time weight was essential in order to secure sufficient traction to make it possible to pull a plow.

It is also important that you clearly visualize the difference of having these small flexibly mounted cutting edges attack the ground one at a time in rapid succession, as against the long knife edge used in previous designs, because this is a fundamental and a prime requisite in the modern efficient rotary tiller.

It is the same kind of a difference you will find in the multiple of small blows of an air-riveter, as compared to the one terrific blow of a heavy sledge.

It took Prof. Von Meyenberg some years to reduce his original design to a satisfactory practical machine. This delay was due in large part to developing the proper spring mounting for his tools. Just as soon as Von Meyenberg reduced his designs to a practical machine, a company was incorporated in Switzerland for their manufacture. Since this time thousands of these new type tillers have been built and sold and are in successful operation today in all parts of the world.

* * *

To give an idea of the efficiency of the rotary tiller, a 5-hp machine cuts 27 in wide, and under favorable conditions will completely pulverize the ground to a depth of 10 in at a rate of 1¾ acres in a ten-hour day. The ground prepared by the rotary tiller in this way will be comparable to the soil on a greenhouse bench; the fertilizer will be evenly and completely distributed from top to bottom, thus greatly overcoming the possibility of burning; there will be no plow sole and no air pockets; the ground will be ready for planting in one operation, and this planting can follow directly after this one operation.

There are many growers who believe the action of the rotary method in thoroughly pulverizing the ground and tossing it up into the air in such a way as to thoroughly areate it, has a very beneficial affect. It is interesting to know that experiments are being carried on by government experimental stations in the hope of eradication of certain pests by the injection of gases under the bonnet while plowing by the action of the engine exhaust. Other experiments are being carried on by the government for the mechanical killing of the Japanese beetle and the white grub by the cutting or blow delivered by the fast revolving tines or cutting tools of the rotary tiller.

A seedbed prepared by a rotary tiller not only holds the moisture better, but it also greatly lessens soil erosion, and this is very important on hillside work, as it permits much quicker absorption of surface water.

It is generally conceded that tender young roots have a much better opportunity for growth in ground that is thoroughly pulverized than in ground prepared in the usual manner, where the roots have to dodge air pockets, force their own way through hard chunks which have not been broken up, and where the fertilizer is located at a long distance from their early growth. And these young plants grown up are not stopped by the hard pan made by the plow sole. I do not think there is any longer the slightest doubt in the minds of practical growers as to the advantage of the ground being thoroughly prepared in this way.

Another interesting point regarding the use of the rotary tiller is where it is used by growers of vegetables under glass. These growers have found that the complete pulverization of the soil saves them many dollars in the amount of coal consumed for the sterilization of their ground. For those of you who are not familiar with this work, it is interesting to know that these large greenhouse growers have steam pipes running under their soil at a depth of approximately 10 in. In order to free the soil from diseases they find it advantageous, after the crop is harvested, to sterilize the soil, thus killing the nematodes which are so destructive to the crops.

Just as it takes less time to bake a small potato than a large potato, so it takes less time to bake the soil when it has been completely pulverized, as against having the ground only broken up into large chunks.

Up to the present time rotary tillers have been built in commercial quantities only for comparatively small acreage use. The Siemens & Halske Company has built a large machine which cuts 66 in wide and to a depth of 15 in. This machine, however, is only practical where it is used for plowing purposes alone, on a sufficiently large scale to warrant the large investment necessary, as this machine is strictly a single-purpose machine and cannot be used as a tractor for other purposes.

For the past three years we have been at work on designs of rotary tillers which can be used in conjunction

with the standard type of tractors, obtaining their power from the power take-off.

It has already been amply and conclusively demonstrated that it is entirely practical with any of the small walking rotary tillers to plow and plant any of the cereals in one operation. This work up to the present time has consisted of dragging back of the rotary tiller a light roller and a conventional planter.

It is our belief that within a comparatively short time it will be possible for the 50 to 100-acre growers to do all of their planting and plowing in one operation with the 30-hp tractor attachment. We have already made some advance in this direction, even to an attempt to turn under a standing cover crop of rye and planting potatoes all in one operation, which has encouraged us to believe that this will be developed and become standard practice.

The future of agriculture, we believe, will largely depend on rotary tillage. The advantages which it offers must, if for no other reason than its economy, bring it to the forefront.

Much planting today in dry areas is done by hilling up, when it would be preferable to have the planting done on flat ground, in this way greatly conserving the moisture. The hilling up is done where the usual tools available make it necessary. With the rotary tiller, flat planting is the normal planting, but the hilled-up planting is just as readily achieved. This is simply done by fastening to the rear of the rotary tiller a deflector somewhat similar in shape to a plow. The dirt thrown out by the rapidly revolving tines against this deflector is displaced and forms the furrow, as desired.

In using the rotary tiller for cultivating, much higher speeds are possible and much greater acreage, of course, can be covered in a day than when plowing deep with those models which have a two-speed transmission.

One cultivation by the rotary method is generally considered, by users, equal to two cultivations by the ordinary method. The entire rotary-tilled surface is finely pulverized, leaving a splendid mulch to conserve moisture, and weeds are so violently treated and tossed up on the surface that they have little opportunity to again come to life.

One of the first questions we are always asked with reference to the rotary tilling idea is the matter of stones. This at one time was a most serious question, but today it no longer bothers us, as breakage or damage from stones has been practically eliminated.

The rotary tiller we have developed is almost evenly balanced on its wheels. It is only slightly heavier in the rear end. Should the revolving tines strike a buried ledge or large rock, its flexible springs will compress until such time as the resistance overcomes the weight of the rear end of the tiller, lifting the whole out of the ground and allowing the tines to roll over the buried ledge or rock. The possible shock in this way is greatly lessened by this balanced design. Smaller stones, or stones as large as a man's head, are dug up and left on the surface, making their removal easy.

We are proud of the fact that we in America have overcome spring breakage by the invention of a very simple shock absorber. It was formerly thought that spring breakage was due to the blow received by the spring. We called in Mr. J. E. Andrew, who is generally regarded as the greatest spring expert in America, to work on our spring problem. It was he who suggested that the springs probably broke from rebound rather than from the blow. We immediately suggested the desirability then of a shock absorber and at once went to work to invent such a device. Many different designs were worked out. Today a very simple rebound check is used. This, together with the great improvement in spring material, has to all intents and purposes completely eliminated spring breakage. We have been most fortunate in being allowed very strong patent claims on this shock-absorbing device.

In ground that is normally easily tillable, it is not necessary to have these shock absorbers or springs of special material, but where the ground is hard or filled with trash or obstructions, the better springs and the shock absorbers are essential. We are going into fields which have been abandoned because of the difficulty of plowing, and we are enabled to use this type of rotary tillage in situations where the ordinary moldboard plow could not work at all, notably where there are buried ledges.

Our cutting tools, of course, will not stand up as long in this stony ground as in normal tillable ground, and we are not yet satisfied with the length of life of our cutting tools. Before we can say that the rotary tilling method is entirely successful for all plowing work, it will be necessary for us to lengthen the life of these tools considerably. We have great hopes of doing this.

We have already more than doubled their life by the use of better steels now available and by stelliting the cutting edges, but we are not satisfied, and until we can go into the ordinary run of farm land and completely pulverize and put in excellent seedbed condition at least 50 acres without the replacement of a tine, we will not feel that we have reached our legitimate goal.

In conclusion, there is one other thing of which I wish to speak. The rotary tiller represents fundamentally the highest type of engineering. It has been worked out by the leading engineers of the world. In construction, material, workmanship, and design, it is in every way on a par with the best automobile practice.

These machines are not assembled articles. There are no exposed running parts. Everything runs in oil and is made as completely dustproof and waterproof as modern means will permit. There is still room for development, however, and we believe that from now on agricultural engineers can, with great profit to themselves, study this new method with the view of still better fitting it to the needs of the growers throughout the world.

Rubber Tires for Tractors

SOME preliminary research studies have been made by the Department of Agricultural Engineering at the Pennsylvania State College with the use of rubber tires on farm tractors. A 15-acre field for potatoes was disked, spring-tooth harrowed, and planted with a tractor equipped with pneumatic tires. No fuel or slippage records were kept in comparison with steel wheels. However, the pneumatic tires worked very satisfactorily.

It appears that the future farm tractor, in many cases, will be mounted on rubber tires. Thus equipped the tractor will have more uses in hauling on the road and about the farm. Already a few manufacturers have put high gears in their tractors which are capable of road speeds around 20 miles per hour. A tractor was driven from Harrisburg to State College, Pennsylvania, under its own power. Combines, threshing machines, wagons, and other portable farm machines are being rubber tired to take advantage of these high tractor speeds. Reports show that there are one million farm tractors now in use on the 6 million American farms. It stands to reason that these power units should serve a wider purpose by being made mobile.—R. U. Blasingame, agricultural engineer, Pennsylvania State College, before a meeting of the A.S.A.E. North Atlantic Section, at Harrisburg, Pa., January 1934.

Electrical Power in the Companionship of Industry and Agriculture[1]

By W. R. Woolrich[2]

ONE OF THE GREATEST lessons taught by the experience of the last half century, terminating in the reactions of the past four years, is that man has placed too much emphasis on his ideal of mass production and too little on the development of his home.

In the industrial area of the eastern part of the United States, this mass production was measured in tons of materials processed or millions of pieces produced. In the great valleys of the Mississippi and Missouri rivers, this same urge of mass production resulted in their measuring prosperity in millions of bushels or pounds of some agricultural product raised. Our educational systems, our banking structure, our laws, and our economic pattern were,—and to some extent still are,—based on making the big bigger, and ignoring the small as unimportant and without cast. The romance of tons and bushels will gradually give way to the more important fundamentals of human betterment. Tons and bushels will be recognized as contributing agencies to the better type of American life, and not the ideal.

The development of the American home with higher cultural values, more artistic appreciation and modeled as a place to live, instead of being looked upon as a mere resting place between Herculean efforts to produce more goods, is essential and inevitable if we are to maintain our leadership as a great nation. The farm home life, with its breadth of experience, has an educational and cultural value that must be not only preserved but should be extended.

Rural electrification holds out great possibilities in the improvement of the farm home. It promises to give the rural dweller virtually all of the advantages of city life without introducing many of the undesirable features to be found in crowded urban centers. The extension of the use of electricity will probably eventually turn the tide of migration from its past movement from farm to city, and give rural America an increasing number of people coming into her areas from whence a generation previous our forefathers left for the city. Many of these will not return to the country as farmers but as suburban residents taking on enough of the rural habits to bring a better mode of life to their families, but affecting but little the net production of agricultural products.

Farm Electrification and the Farm Debt. Any proposal for a rapid expansion of farm electrification must be examined for its economic soundness. As is evidenced by Fig. 1, many of the difficulties the farmers of some areas are now experiencing are the result of too much credit being extended to them in days of apparent prosperity. A comparison of the mortgage load of 1930, expressed in terms of the number of years it will take the entire farm crop to pay such mortgage, shows that the more fertile mid-western states where loans were readily extended, are today much worse off than the southeast where farm loans were obtained with great difficulty.

If any attempt is made by any promotional agency to induce excessive installment buying of home and farm equipment, including electrical devices, such effort must be examined for its soundness. One of the most important criteria for the determination of whether the electrical devices should be sold to the farmer is "Will this device help to pay off the farm mortgage, or will it just lead the buyer into greater mortgage debt?"

Failure to face this question squarely has brought great criticism to farm equipment dealers, and rightly so. An organization, such as the American Society of Agricultural Engineers, can today contribute as much to the American farmer by helping to set some sane economic criteria on equipment purchasing as they can in any one endeavor.

Some concrete examples might serve to illustrate this statement. Under the enthusiasm of high returns from their farms, small farm owners purchased tractors in 1922 for $600 to $700. With certain soils, some of those tractors were unfit for service after plowing 600 acres. The direct machine charge against each acre plowed was at least $1 per acre. To this must be added repairs, oil, gasoline, and labor. To justify our economics, we compared this cost to that of a $400 team eating $300 worth of feed a year. We verily "kidded" ourselves in believing this was good economics, when we knew only too well that most of America's plowing was done by horses and mules costing less than $125 per team,—and that team was fortunate if it received $100 worth of feed per year.

Electrification Program. A satisfactory farm electrification program requires:

1 A rate low enough to compete with existing light and power sources.

2 An added income for any extended use that will more than pay for the increment of power used.

3 Equipment costs that are basically sound.

4 The end of manufacturers' experimenting at the expense of the farmer.

5 Either cash purchasing, or an installment buying program that can be economically justified.

Rates. Rate bases in many states have been a subject of

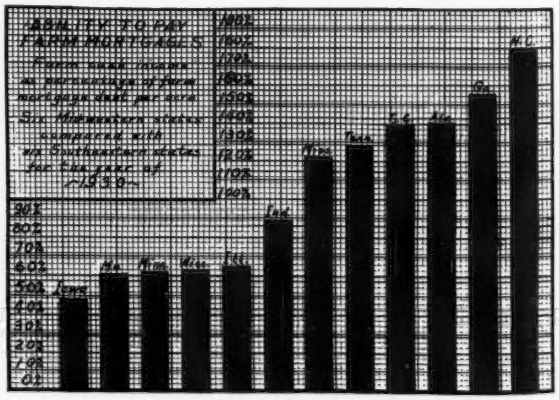


FIG. 1

[1]A paper presented at a meeting of the North Atlantic Section of the American Society of Agricultural Engineers, at Harrisburg, Pa., January 1934.

[2]Mechanical engineer, Tennessee Valley Authority.

question. Some points of controversy before rate commissions have been:

1 Using a liberal depreciation to maintain a high rate schedule but failing to reduce the capital investment by such annual depreciation figure.

2 Maintaining a high bonded indebtedness and charging the bond interest as a legitimate expense.

3 Permitting unessential poles and equipment to exist to hold up the capital valuation.

4 Charging a high valuation on the cost of the pole line, permitting the farmer to pay for this pole line, but still keeping it on the company books as utility property.

5 Purchasing properties in excess of actual cost.

It has recently been pointed out by some of the utilities' executives that the urge has been to maintain a high power rate by such representation before commissions, but the future plan will probably be to appeal for a low rate to encourage a more widespread use of the current by every home.

It has been the unfairness of some of these practices that has undermined the American confidence in some utilities.

Income from Equipment Purchased. Diversity will necessarily become more and more the keynote to our American economics. The electrical equipment for the farm should have a wide diversity of application thus permitting a high use factor. Portable farm motors, refrigeration units that would suffice for both dairy and household needs, and pumps constructed for diverse applications, are typical examples of probable new developments. Agricultural engineers are going to need to watch that type of salesmanship that encourages an individual motor on every unit when often a grouping is far more economical in investment.

Equipment Costs. There has been much of the "racket" element in electrical merchandising. The washing machine manufacturer that pays $50 to the distributing retailer for each unit sold; the electrical stove maker who pays $50 to his dealer to sell a stove at $140 that has an actual worth of approximately $45; or the hot water heater corporation who sells an elaborately designed unit at $150 when a simple $50 heater would do the job equally as well or maybe even better, should be eliminated. If manufacturers of such devices cannot remove the racket odor from such transactions, the American ruralists will find it necessary to go into cooperative manufacturing enterprises in self-defense.

The newly created Electrical Farm Home Authority has been organized to lead the way in a fair demonstration of what can be done to give relief in this phase of farm electrification.

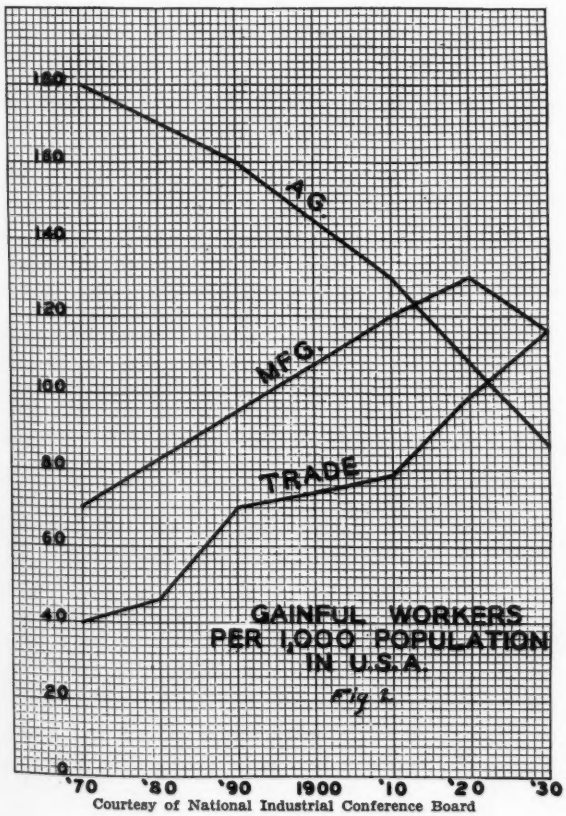
Closely related to this high-distribution sales charge is the established habit of declaring equipment obsolete within a short period of time after selling, and make it necessary for the owner to buy new equipment just as soon as the used piece wears out one part.

Recently a nationally advertised refrigerator company salesman announced to the writer that an available six-year-old electric refrigerator would be an unprofitable buy because it would be impossible to supply repair parts for it once it stopped working. Fortunately, this same writer had to purchase two refrigerators and was considering this used box together with several propositions on a new unit to meet the requirements.

The manufacturer of the old unit was also the low bidder on the new, but he wanted to sell two new boxes instead of permitting the old box to be put into use. He appeared at the purchasing department to get his order signed. It was refused on the basis that any company that sold electric refrigerators that admitted their machines were obsolete in six years deserved no business consideration.

Within less than an hour, that company discovered they could put that used unit in excellent order, furnish all the necessary repair parts at any time for some years to come, and all for the same price as one new refrigerator would cost.

Experimenting at Purchaser's Expense. Many manufacturers of America have maintained inadequate testing laboratories of their own, and have carried on much of the cost of experimenting at the expense of the purchaser. With farm equipment, this difficulty is much more likely to exist



Courtesy of National Industrial Conference Board

FIG. 2

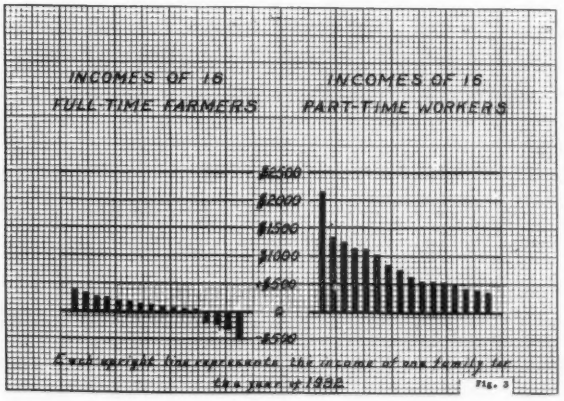


FIG. 3

POLE ERECTION ON THE TRANSMISSION LINE BEING BUILT BY THE TENNESSEE VALLEY AUTHORITY BETWEEN WILSON AND WHEELER DAMS. THIS WILL SERVE AS A RURAL TRANSMISSION LINE AS WELL AS FURNISH POWER FOR THE CONSTRUCTION OF WHEELER DAM

than with industrial machines since the farmer usually does not have a consulting engineer available to defend his interest. The extension of cooperative buying will do much towards eliminating this practice, but probably the supplier of the power should himself take a greater interest in the farm purchaser and provide this service of testing and standardizing equipment that he is ready to recommend without reservation.

Cash Purchasing. Any program for rural electrification should hold installment buying on a safe basis. A farmer's income is too unassured and variable to permit him to justify long-term obligations. A recent example of a dairy farmer receiving a $17 monthly light and power bill and in the same mail a $14 check as his month's dairy herd receipts deserves serious consideration, even if the story lacks authenticity.

Electrical equipment on the farm should offer the farm owner some labor relief. If it makes his work much harder than before, just because he has to keep up with the electric bill mailed him monthly, then it has missed its purpose and should not be considered.

Distribution Problem. Not a little of the impeding force toward farm electrification has been brought about by unwarranted line cost barriers. Not an uncommon occurrence has been a request of the farmer to pay for an extension line at the rate of $50 per pole plus the other material and labor cost, this to be paid for in monthly installments over a spread of years, but, when paid for, to still be the property of the utility. The concession given the farmer was the long period allowed for line-cost payments. Farmers who offered to build the line themselves to the standards supplied by the utility, were refused even consideration.

There are not many areas in the United States where standard rural pole lines cannot be constructed for $700 to $1,000 per mile. Fully 20 to 25 per cent of this represents a type of labor the farmer can contribute himself. Six hundred dollars of material money will build good standard pole lines in most areas.

When we consider that county highways cost from $2,000 to $28,000 per mile, depending upon the construction, it is not a very long step in our thinking to visualize every rural highway supplemented by an additional $800 to $1,000 expenditure to completely electrify the rural areas. Then why not consider a future goal of complete county electrical distribution with a county agricultural engineer in charge.

Just who shall finance and build these distribution systems is a problem this or similar organizations could well help determine. Three probable agencies suggest themselves: (1) The utility company, (2) by cooperative farm groups, and (3) county or other governmental agency.

Utility Construction. This has the advantage that the supplier and builder are the same parties and can give well-coordinated service if they so desire. Further, it relieves the farmer of having to supply maintenance supervision of the system.

Cooperative Farm Construction. Virtually no cooperatively owned rural electrification lines have been built in America. This is partly due to the unfortunate record of farm cooperatives in America, partly due to the failure for the proper agricultural engineering leadership in most rural areas. It has not been attempted under farm credit financing on account of the past limitations of such financing to farm application alone, which eliminated its use in the farm home if so financed.

County Financing. Any attempt to use county funds on a farm electrification project should first be guarded by some standard type of law requiring other than political specifications for the engineer, the lines materials, and the locations. Such a study should well be undertaken by some standardizing body.

Farm Electrification and the Diffusion of Industry and Agriculture. Fig. 2 indicates very emphatically that the continued normal trend is for less and less farm workers to be needed to supply America's needs for agricultural products. When it is considered that the capacity of a given total population to consume food is relatively constant irrespective of cash income and price levels, then it becomes evident that new methods of mechanizing agriculture must necessarily relieve more and more workers from farm labor, unless the other alternative of shortening hours of work is accepted.

On the other hand, the capacity of a given population to use products other than foodstuffs is mostly a function of their income. Any adjustment that would give them a greater income will likewise increase their demand for such articles. The production of manufactured products per man employed in their production has also expanded rapidly over a long period and must be expected to increase in the future for each man-hour given to manufacturing.

The increase of employment in the fine arts offers a limitless field of unemployment, but the expansion will be slow in this field since it is dependent upon the process of reeducating ourselves for a greater appreciation of the artistic. Further, the very nature of this field of endeavor imposes a long period of near starvation for the embryo artist that only the most persistent will endure.

These several considerations indicate that the most feasible method of meeting the problem is to enable large numbers of the rural people now living in rural areas to find industrial employment by locating more and more of our *new* industries in rural United States, thus supple-

menting the farm income by some cash wages from the manufacturing enterprises.

That this method brings a much more desirable living income to the rural area is evidenced by Fig. 3. In a county area of good agricultural conditions, a random selection of 16 farmers showed an average net income of about $150 for 1932. In the same area, the random selection of farmers having a supplementary income from industry showed an average net income of $850. In considering Fig. 3 for 1932, it must be remembered, however, that it was an unusually unfavorable year for agricultural products. With a more favorable year, the advantage of the supplementary income would not be as pronounced.

Into such a program farm electrification becomes an integral part. The establishment of such small industries helps to carry the burden of line cost and overhead expense, thus assuring a higher degree of electrical maintenance service. At the same time, the weekly cash income from the industry makes possible the prompt payment of power bills and brings virtually all of the conveniences of the city to the rural home, thus raising the standard and attractiveness of farm life equal to or above that of the modern city home.

The question naturally presents itself: What can we manufacture that will not put some other American industry further in debt? It must be recognized that America still imports millions of dollars worth of products that can just as economically be made in America. Our *plenty* has never taxed our resourcefulness seriously before, but today research America is actively at work preparing to command much of this business previously neglected.

The Electric Home and Farm Authority

The Electric Home and Farm Authority can best be briefly explained by the statement of Director Lilienthal:

> The plan, in brief, is as follows: The manufacturers of electric equipment have indicated their willingness to participate in a program of producing certain types of standard-quality, low-cost, electric-using appliances. These will be offered for sale by the existing dealer outlets, at prices very substantially lower than any heretofore known. These manufacturers will cooperate with Electric Home and Farm Authority in certain research and educational activities designed to bring home to people of the area the most economical and most satisfactory ways of using electricity in the home and on the farm. Further, Electric Home and Farm Authority will arrange for a more satisfactory basis for the financing of electric appliances. While the Reconstruction Finance Corporation will, in effect, guarantee ten million dollars of consumer paper, we are confident that the actual credit will come through the commercial banking system, which has been looking for just such high type of consumer paper, consistent with the needs for liquidity. The cost of financing to the consumer will be greatly reduced, due in considerable part to a cooperative arrangement whereby collections will be made by the utility company on the consumer's electric bill rather than through a separate and duplicating medium.

The standard case offered as an example of how the Electric Home and Farm Authority is expected to work is as follows:

Mrs. Jones will go to an existing dealer in electrical appliances in her home town and select a typical piece of farm equipment such as a portable motor or water pump or other accessory. She will sign appropriate papers and the dealer, after her credit has been passed on, will transmit these papers to the Electric Home and Farm Authority, which will pay the dealer in cash and the dealer's responsibility except as to contingent credit losses, will be through. Delivery will then be made to Mrs. Jones.

In order for the plan to be open to the dealer and to Mrs. Jones, it will be necessary that the local electric company shall have submitted rates to the EHFA which meet that agency's approval as being low enough to make the use of such appliances feasible for people of small income. Each month the local electric company will add to Mrs. Jones' bill for electric energy an item which in four years will amortize the total commitment for appliances together with interest. These collections the electric company will remit to the Electric Home and Farm Authority.

The capital of the Electric Home and Farm Authority consists of $1,000,000 capital stock held for the United States by the three members of the board of the Tennessee Valley Authority and $10,000,000 of credit extended by the RFC.

Standardization and Simplification of Farm Electrical and Refrigeration Equipment. This is a pressing problem if the farmer is to be protected. At the present date, the farm purchaser will find:

1 That if he secures the available designs and recommendations from state extension divisions, they will be in disagreement.

2 If he asks the salesmen to diagnose his needs, the recommendations will vary very widely.

3 If he tries to work out the problem for himself, it becomes too technical for a layman's solution.

Is it not possible that we have spent too much time in our engineering laboratories testing out equipment that manufacturers offered for sale rather than working out a minimum standard to which they should conform?

If a farmer calls for bids on milk-cooling equipment to cool forty gallons of milk each night and morning, he probably will fail to place any specifications on cooling time, temperature required, outside temperature conditions, length of life of equipment, type of control, overload capacity, drainage, heat loss, adaptability to other cooling, etc. His probable bidders will include those who have specialized in household refrigeration and those who have featured larger commercial refrigeration equipment.

Commonly, there will be some bidding from the former group that will be entirely too optimistic about their machines and offer equipment that is entirely too limited for the job. And just as commonly, there will be some bidders from the latter group who will propose a machine of such proportions and characteristics that the price quoted will be far beyond the farmer's ability to pay.

A large corporation having extensive needs for service equipment of similar characteristics soon finds it advisable to formulate a definite specification of minimum requirements for such equipment. In rural America there are thousands of farms having similar equipment requirements. Have our technical and professional societies together with our federal and state agencies, including our colleges and universities, been as alert in safeguarding the interests of our farm purchasers as a corporation does in meeting the needs of its departments or branch agencies.

The Agricultural-Industrial Division of the Tennessee Valley Authority is now preparing certain specifications of minimum requirements for electrical and refrigeration equipment that will be acceptable for their farm users. Such standards will permit manufacturers to reduce the cost of sales service and eliminate considerable of the responsibility now placed upon salesmen. Likewise, it will make it possible for the farmer purchaser to have some assurance that he is buying to meet his definite needs.

If such standardization of minimum specifications could be coordinated throughout the United States, it would be of great value to both manufacturer and user.

The valley of the Tennessee River has been set aside as a national research laboratory for a planned development of our resources, both social and material. It invites the national groups such as the American Society of Agricultural Engineers to participate in its program. And in the same spirit of cooperation, it solicits your suggestions and counsel in the framing of its program.

Alcohol-Gasoline Blends as Engine Fuel[1]

By R. B. Gray[2]

THE USE OF ALCOHOL-GASOLINE blends as fuel in internal-combustion engines has come to the fore during the past year or so, principally because of the possibility of the relief it might afford the farmer in the disposing of his surplus agricultural products.

In foreign countries agitation of a similar nature has taken place, with the result that altogether a considerable mass of information has been accumulated, the analysis of which, however, leaves the subject still more or less controversial, especially in the United States.

Be that as it may, the investigations have brought out many pertinent points which will prove valuable—if not immediately, then at a not very distant date (perhaps in two decades) when, it has been predicted, our petroleum resources will be used up.

Natural resources are not inexhaustible. If the countryside is denuded of forests, trees can be planted. If the soil fertility becomes depleted, a soil-building program, the use of fertilizers, etc., can be employed for restoring it. Not so with petroleum. If this natural resource fails, then other sources of engine fuels must be sought.

If alcohol, as has been proposed, were mixed with gasoline, the drain on the petroleum reserves would be lessened. Then, when an actual scarcity became evident, the per cent of alcohol could be increased until—who knows—eventually alcohol alone could be used, as is the case in some of the tropical regions. According to the present outlook, there would be no difficulty in raising an abundance of agricultural products from which to make alcohol. Incidentally, this would provide more uniform fuel because, according to the chemists, the make-up of alcohol, regardless of source, is quite uniform. By that time, too, methods of producing alcohol might be found that would be more efficient even than those now used. The need for all of this may right now appear to be remote, but it does not seem that the subject should be passed over as idle chatter.

In reviewing available information on the performance of alcohol-gasoline blends as engine fuels, for mixtures up to 20 per cent of absolute alcohol and regular gasoline, there appear to be no significant differences in the findings of different investigators other than what might be attributed to experimental errors. As the 10 per cent blend has been given the most attention in this country, it will be given principal consideration in this paper.

At the outset, a review of a few physical-chemical properties of alcohol and the blend might be pertinent.

Absolute or anhydrous alcohol (99.5 to 99.9 per cent) containing practically no water, will mix with gasoline in practically any proportion.

The heat value (lower) of absolute alcohol is about 11,500 Btu per pound as compared with about 19,000 Btu per pound for gasoline, or, on a volume basis, 79,000 Btu per gallon for alcohol and about 115,000 Btu per gallon for gasoline. On this basis, therefore, a 10 per cent blend of absolute alcohol and regular gasoline would contain about 97 per cent of the heat units contained in a gallon of gasoline. Incidentally, this 3 per cent difference might be found among different brands of gasoline.

The latent heat per unit volume of alcohol is said to be about three times that of gasoline; that is, about three times as much heat is required to evaporate unit volume of alcohol as gasoline. The presence of 10 per cent alcohol in a blend, therefore, would have a corresponding cooling effect and make a denser charge which would practically offset the lower heat value. L. M. Christensen and others at Iowa State College have shown that there is a drop of nearly 11 deg F when evaporating a 10 per cent blend as compared with plain gasoline.

Pure alcohol, according to Ricardo, will withstand a compression ratio without detonation of about 10 to 1, and plain gasoline about 5 or 6 to 1, depending on cylinder head construction, valve arrangement, and manifolding. This anti-detonating property of alcohol in a 10 per cent blend permits raising the compression for the mixture considerably.

The fuel-air ratio of absolute alcohol for best performance is, according to the literature, about 9 to 1, with plain gasoline about 15 to 1, and with the 10 per cent blend about 14 to 1. It is stated that the range of fuel-air ratios within which alcohol will burn is considerably greater than for gasoline alone, so that the presence of alcohol would tend to make smoother performance even with a carburetor setting considerably out of adjustment for gasoline. More complete combustion also appears to be possible, which in turn should make for less carbon formation.

TABLE I. FOUR-CYLINDER NAVY GASOLINE ENGINE TESTS

Fuel	Speed, rpm	Brake horsepower	Torque lb-ft	Fuel consumption: bhp-hr per gal	Fuel consumption: lb per bhp-hr	Throttle opening
Gasoline	910	11.14	64.26	7.30	.835	
"	915	11.35	65.10	7.44	.819	
"	903	14.93	86.84	7.74	.787	half
"	905	16.29	94.50	7.47	.816	full
"	900	16.09	93.87	7.85	.776	full
"	900	15.57	90.83	7.90	.772	half
"	895	6.50	38.12	5.97	1.020	
"	700	12.10	90.72	7.62	.802	half
"	700	12.10	90.72	7.44	.821	full
"	700	12.07	90.51	7.47	.815	half
"	603	10.40	90.51	7.27	.836	half
"	603	10.42	90.72	7.17	.850	full
Gasoline	906	15.46	89.57	7.90	.777	half
plus 10%	904	15.35	89.15	7.96	.775	half
alcohol	900	16.34	95.34	7.77	.793	full
"	705	12.17	90.62	7.80	.790	half
"	700	12.18	91.35	7.93	.777	half
"	700	12.17	91.24	7.75	.793	full
"	603	10.48	91.24	7.55	.815	half
"	600	10.46	91.56	7.60	.810	half
"	600	10.44	91.35	7.65	.805	full
Gasoline	900	14.63	85.37	7.80	.798	half
plus 30%	900	15.55	90.72	8.13	.767	half
alcohol	900	16.52	96.39	8.05	.774	full
"	700	12.54	94.08	8.14	.765	half
"	700	12.54	94.08	7.97	.780	full
"	600	10.49	91.77	7.80	.800	half
"	600	10.94	95.76	7.83	.797	half
"	600	10.84	94.81	7.75	.805	full

[1]Paper presented at a meeting of the North Atlantic Section of the American Society of Agricultural Engineers held at Harrisburg, Pennsylvania, January 1934.

[2]Chief, division of mechanical equipment, Bureau of Agricultural Engineering, U. S. Department of Agriculture. Mem. A.S.A.E.

[3]The stationary-engine tests, octane ratings of the fuels, and blending observations were conducted in cooperation with the U. S. Navy Department at the Annapolis Engineering Experiment Station, where scientific instruments and test equipment are available.

TABLE II. TRUCK TESTS

Fuel used	Average distance traveled, miles	Average duration of test, hr-min	Ave speed, mph	Ave mpg of fuel
½-ton—no load				
Gasoline	83.33	2 — 19	36.0	16.67
10% Alcohol	83.28	2 — 18	36.2	16.66
20% Alcohol	79.62			15.92
1½-ton—net load, 3380 lb				
Gasoline	63.66	2 — 24	26.5	12.73
10% Alcohol	63.40	2 — 24	26.4	12.68
20% Alcohol	63.10	2 — 23	26.5	12.62
Ave engine speed at 25 mph, 1475 rpm; at 30 mph, 1775 rpm				
3½-ton—net load, 7700 lb				
Gasoline	27.16	1 — 54	14.3	5.43
10% Alcohol	28.97	2 — 02	14.2	5.79
20% Alcohol	29.25	2 — 04	14.2	5.85

Seconds Required for Given Acceleration on ½-Ton Truck			
Miles per hour	10 to 40	20 to 40	10 to 30
Gasoline	15.2	10.6	10.2
10% Alcohol	15.6	10.8	10.1
20% Alcohol	15.7	10.8	10.4

For a given compression, the flame temperature of the alcohol blend appears to be somewhat less than that of gasoline alone. This would tend to slightly increase the thermal efficiency. Likewise, the rate of flame propagation appears to be less than gasoline, which may account in a measure for better economy at lower road speeds reported by Iowa State College and others.

The boiling point of pure alcohol is about 173 deg F. On the distillation curve for present-day gasoline, the initial boiling point temperature is about 100 deg and the final about 400 deg, depending somewhat upon the season and the type of gasoline. Poured together, the two fuels form an azeotropic mixture which would be expected to boil at a temperature lower than either one. According to Christensen, however, the initial boiling point of a 10 per cent blend is slightly raised. This seems to make very little difference in starting, but the other characteristics should minimize the tendency for vapor lock.

Observations made by the Bureau of Agricultural Engineering, U. S. Department of Agriculture, on the performance of alcohol-gasoline mixtures compared with straight gasoline as fuels in tractors, trucks, and stationary engines, indicated in general no outstanding differences[3].

Octane Rating. Anti-knock (octane rating) tests of the three straight gasolines, made on an N.A.C.A. engine, gave ratings of 67, 66, and 66; with an admixture of 10 per cent alcohol (absolute), ratings of 75, 74, and 73, respectively; with 20 per cent alcohol admixture, ratings of 80, 80, and 79 (approximating ethyl gasoline which was 78 when these tests were made); and with an admixture of 30 per cent alcohol, ratings of 85, 85, and 84. While the anti-knock properties may vary from the foregoing, in engines of different design and operation conditions, the N.A.C.A. engines permitted study of this property as affected by the addition of alcohol to the gasoline.

H.U.C.R. Tests. On this same engine running at 1200 rpm and with a cooling temperature of 180 deg F, the highest useful compression ratio (H.U.C.R.) of a straight gasoline was found to be 5.6 and the maximum brake horsepower 24.6; with a 10 per cent admixture of absolute alcohol, the H.U.C.R. was 6.1 and the maximum brake horsepower 26; and with a 20 per cent admixture of alcohol, the H.U.C.R. was approximately 6.5 and the maximum brake horsepower 27.2.

Stationary Engine Tests. Tests on a Navy B. A. four-cylinder, 3½x5-inch L-head engine (Table I) showed that on straight gasoline the maximum horsepower at full throttle varied from 10.40 at 603 rpm with 7.27 bhp-hr (brake horsepower-hours) per gallon to 16.29 at 905 rpm and 7.47 bhp-hr per gallon of fuel. The maximum torque was 94.5 lb-ft at 905 rpm.

This engine was fitted with a carburetor in which the same jets and adjustments were used throughout the series of tests. The spark produced by magneto was manually controlled and set at what seemed to be the best position for each test. The speed was varied from 600 to approximately 900 rpm with full and half-throttle openings. The outlet temperature of the cooling water was maintained at 160 deg F. While this type of engine is used by the U. S. Navy in small launches, it is an exact copy of a former truck engine.

Truck Tests. Road tests of a ½, 1½, and 3½-ton truck (Table II) over a 20-mile course laid out on paved highways gave the following results: The unloaded ½-ton truck driven at an average speed of 36 mph (miles per hour) ranged from 16.67 mpg (miles per gallon) on straight gasoline to 15.92 mpg on the 20 per cent absolute alcohol admixture. The 1½-ton truck with a net load of 3380 lb and driven at an average speed of 26.5 mph ranged from 12.73 mpg on straight gasoline to 12.62 mpg on 20 per cent alcohol admixture. The 3½-ton truck with a 7700-

TABLE III. TESTS ON TRACTOR NO. 1 (FOUR-CYLINDER)
(Compression Ratio, 4.35 to 1)

Fuel	Speed of engine, rpm	Brake horsepower	Fuel consumption: bhp-hr per gal	Fuel consumption: lb per bhp-hr
Maximum Load				
Reg. gasoline	1036	31.8	6.0	1.01
10% Alcohol	1008	31.6	6.4	0.95
20% Alcohol	1005	31.6	6.3	0.90
Rated Load (85% of maximum)				
Reg. gasoline	1016	27.15	7.5	0.81
10% Alcohol	1014	27.4	5.9	1.04
10% Alcohol (check)	1017	27.4	6.2	0.97
20% Alcohol	1011	27.0	6.2	0.99
Half Load				
Reg. gasoline	1027	16.3	6.4	0.95
10% Alcohol	1005	15.7	4.7	1.30
10% Alcohol (check)	1005	15.7	4.7	1.31
20% Alcohol	1011	15.8	4.9	1.25
Quarter Load				
Reg. gasoline	1014	8.8	4.0	1.52
10% Alcohol	1023	8.5	2.8	2.16
20% Alcohol	1017	8.5	3.1	1.94

TABLE IV. TESTS ON TRACTOR NO. 2 (FOUR-CYLINDER)
(Compression Ratio, 6 to 1)

Fuel	Speed of engine, rpm	Brake horsepower	Fuel consumption: bhp-hr per gal	Fuel consumption: lb per bhp-hr
Maximum Load				
Ethyl gasoline	1020	46.4	8.34	0.71
20% Alcohol + 80% Reg. gasoline	1017	46.3	9.26	0.67
Rated Load (85% of Maximum)				
Ethyl gasoline	981	36.5	7.95	0.74
20% Alcohol + 80% Reg. gasoline	999	37.2	8.25	0.74
Half Load				
Ethyl gasoline	1008	22.1	7.87	0.75
20% Alcohol + 80% Reg. gasoline	1014	22.2	7.92	0.78
Quarter Load				
Ethyl gasoline	1002	11.7	5.69	1.03
20% Alcohol + 80% Reg. gasoline	1014	11.8	5.38	1.15

lb net load and driven at a governed speed of 14.2 mph ranged from 5.43 mpg on straight gasoline to 5.85 mpg on the 20 per cent alcohol admixture. The respective speeds of the truck engines were approximately 1700 rpm (calculated), 1500 rpm (calculated), and 1420 rpm (governed).

Routine tests on several trucks have been under way for several months. One pair of ½-ton trucks averaging 2000 miles, one working on plain gasoline and the other on 10 per cent blend, showed a mileage slightly in favor of the blend. Another pair averaging 4500 miles, one working on plain gasoline and the other on the 10 per cent blend, showed a mileage slightly in favor of gasoline. This latter pair were started on the test while new. At the end of about 2000 miles the cylinder heads were pulled and showed a carbon accumulation considerably greater in the engine using plain gasoline. Without removing the carbon, the heads were replaced and the cars were run about 2500 miles further and examined. This time any difference in carbon formation was difficult to detect.

On three 1½-ton trucks, there was a greater difference in fuel economy between the two that operated on gasoline than between them and the third truck which burned a 10 per cent blend.

Several thousand miles of operation of a six-cylinder sedan, using first plain gasoline and then a blend, showed a mileage slightly in favor of the gasoline. With the blend, less knocking was apparent on hills but acceleration tests showed no difference.

Each of the truck tests was made on a 5-gal lot of fuel. After the engine was thoroughly warmed up, the test fuel was switched on and the run started and continued until the fuel was used up. The carburetor settings, which were made originally for gasoline, remained the same throughout the series of tests. (In the preliminary tests, when 30 per cent admixture was used, the carburetor needle valve required further opening.)

In this series of tests a slight improvement in favor of the alcohol admixture in the 3½-ton truck is noted, whereas there was a slight difference in favor of the gasoline with the 1½-ton truck, and somewhat greater difference in favor of gasoline in the ½-ton truck. The different trends might be in part attributed to the difference in engine speeds, alcohol mixtures probably working more efficiently at the lower speeds.

Acceleration tests on the ½-ton truck (empty) showed that it required 15.2 sec to increase from 10 to 40 mph on straight gasoline, 15.6 sec on 10 per cent admixture, and 15.7 sec on 20 per cent admixture. In accelerating from 20 to 40 mph, the time interval ranged from 10.6 sec on straight gasoline to 10.8 sec on 20 per cent admixture.

TABLE V. TESTS ON TRACTOR NO. 3 (TWO CYLINDER)
(Compression Ratio, 3.8 to 1)

Fuel	Speed of engine, rpm	Brake horsepower	Fuel consumption: bhp-hr per gal	Fuel consumption: lb per bhp-hr
	Maximum Load			
Reg. gasoline	800	31.7	7.7	0.80
10% Alcohol	801	32.2	7.6	0.82
20% Alcohol	800	31.3	7.8	0.81
	Rated Load (85% of Maximum)			
Reg. gasoline	799	26.3	7.3	0.84
10% Alcohol	802	27.3	7.0	0.89
20% Alcohol	797	27.3	7.0	0.89
	Half Load			
Reg. gasoline	793	15.8	4.8	1.31
10% Alcohol	796	15.9	4.9	1.25
20% Alcohol	799	15.9	4.8	1.29
	Quarter Load			
Reg. gasoline	801	8.2	2.7	2.25
10% Alcohol	795	7.8		2.32
20% Alcohol	794	7.7	2.7	2.31

Tractor Tests. Tests of tractors were made both on the brake and in the field plowing. With Tractor No. 1 (Table III), with a compression ratio of 4.35 to 1, the power at the brake at maximum load was 31.8 hp for regular gasoline and 31.6 hp each for the 10 per cent and the 20 per cent blends.. The fuel consumption in pounds per horsepower-hour was slightly greater with gasoline alone than with the blends. On the other hand, at normal load (85 per cent of maximum), at half-load, and at quarter-load, the fuel consumption was slightly less on gasoline.

With Tractor No. 2 (Table IV), with a compression ratio of approximately 6 to 1, the maximum power on both premium fuel and 20 per cent alcohol blend was approximately the same, viz., 46.4 hp. The differences in fuel consumption between the two fuels at maximum, normal, one-half, and one-quarter loads were but slight. Tests on plain gasoline and 10 per cent blend were not made because of the severe detonation.

Tractor No. 3 (Table V), with a compression ratio of 3.8 to 1, gave a maximum power at the brake of 31.7 hp on gasoline alone, 32.2 hp on 10 per cent blend, and 31.3 hp on 20 per cent blend. The brake horsepower-hours per gallon varied from 7.6 to 7.8 on normal, half, and quarter loads. Only a slight variation was noted in fuel consumption between the three fuels.

In a series of plowing tests with Tractors Nos. 1 and 3, and a fourth tractor (Table VI) slightly more gasoline than blend was used per acre. There was no difference either way, however, when compared on the basis of drawbar horsepower-hours per gallon of fuel. In these tests the blend was alternated with regular gasoline in the same tractor, with field and other conditions as nearly identical as possible.

Replies to inquiries sent to eight tractor manufacturers in the United States were for the most part not unfavorable to the use of alcohol fuels. Two reported probably increased cost of operation; one reported greater cylinder wear due to blends; another reported no corrosive action found over a long period of time, and smoothness of running very noticeable; and two others reported power, acceleration, and fuel economy practically alike.

The use of alcohol in foreign countries appears to be increasing to a marked degree. One American company operating in England markets an alcohol blend.

Data from twenty countries compiled by Mr. Christensen of Iowa State College show that ten countries have legislation requiring the use of such blends. Apparently, however, the large development of the use of engine alcohol did not depend upon legislation, but was well established before the legislative steps were taken. The prime

TABLE VI. PLOWING TESTS (Spring 1933)*

Tractor	Acres plowed	Soil	Approx. speed, mph	Fuel	Gal per acre
No. 1	5.20	heavy	3	gasoline	4.44
1	4.52	heavy	3	10% alcohol	4.28
1	1.00	light	3	gasoline	4.07
1	3.39	light	3	10% blend	3.94
3	6.44	heavy	2¼	gasoline	3.28
3	5.81	heavy	2¼	10% alcohol	3.05
3	1.16	light	3	gasoline	3.36
3	1.42	light	3	10% blend	2.88
4	1.30	dry and hard	3	gasoline	4.14
4	1.31	dry and hard	3	10% blend	3.93

*Each line represents average of several tests so as to average up soil variations.

motive abroad for fostering the use of alcohol in engine fuels seems to have been to establish better trade balances and to aid in the disposal of surpluses from various agricultural industries.

Use of alcohol as an engine fuel in the United States, it appears from the foregoing, should present no special mechanical difficulties. The use would seem to be merely a matter of economy. It has been reported that with corn at 50 cents per bushel the substitution of a 10 per cent blend for plain gasoline would increase the cost of fuel to the motorist about 3 cents per gallon, but not without certain offsetting benefits. Time does not permit discussion of this phase of the subject. However, the matter has been presented at some length in a report, entitled "Use of Alcohol from Farm Products in Motor Fuel," compiled by several bureaus of the U. S. Department of Agriculture, and printed as Senate Document 57, 73d Congress, 1st Session (1933).

Insect Pest and Plant Disease Control[1]

By R. M. Merrill[2]

THE PROBLEM of controlling insect and disease pests of crop plants is important to agricultural engineers, since many of the control measures recommended for the various pests involve the use of engineering knowledge. The annual economic loss to the United States due to insect pests of all kinds has been estimated by Metcalf and Flint ("Destructive and Useful Insects") as approximately $1,590,000,000. The loss due to plant diseases has been estimated to be about the same as the loss from insects, making the total loss from insects and plant diseases of considerable economic importance.

The Power and Machinery Division of the American Society of Agricultural Engineers has set up the "Committee on Insect Pest and Plant Disease Control." The Committee presents this brief report in order to bring the subject before the members of the Society in the hope that members not on the Committee will assist with suggestions as to how the Society can best aid other agencies which are working on the problem.

An effort has been made to determine how extensively agricultural engineering has participated in this work in the past and to formulate plans for future work. However, it has not been possible thus far to get opinions and suggestions from all the members of the Committee, so only a preliminary report can be offered at this time.

Agricultural engineers have given considerable assistance in pest control in recent years, cooperating with the entomologists and plant pathologists, a partial list of the work being as follows:

1 A study of stationary and portable spray outfits, which includes studies of performance of spray guns, pressure losses, and materials to withstand corrosion.

2 In developing various methods of applying poison dusts, both on a small scale and by airplane, considerable work has been done.

3 Washing of poison residues from different fruits and vegetables has received considerable attention by various agencies.

4 Experimental burners have been constructed and tests have been carried on for the control of European corn borer, pea aphis, apple curculio, and rice root rot. This work has been done by the agricultural engineering divisions of the California and Arkansas agricultural experiment stations and by the Bureau of Agricultural Engineering of the U. S. Department of Agriculture. Burning methods have also been used for cleaning up pens and yards of various animals.

5 Sterilization of soil and various plant material has been carried on by numerous agencies. Electricity, steam, and temperature-control have been used for this purpose.

6 Fumigation is being used rather extensively for treating stored grain, flour, cotton, fruits, and berries. This is done by use of different kinds of gas.

7 The Bureau of Agricultural Engineering and some manufacturers of farm equipment have made alterations in endgate seeders and lime sowers to adapt these devices for spreading poison bran bait for grasshopper control.

8 Some pests are controlled by irrigation and others by drainage.

9 Electric lights have been used both for trapping and for repelling insects. Some studies have been made as to the effect of different light rays on insects.

10 For many insect and disease pests, clean plowing is an effective control measure. The Bureau of Agricultural Engineering in connection with its work in corn borer control has put forth considerable effort to improve quality of plowing by use of attachments for plows and by more effective plowing methods. Clean plowing is considered especially important, since besides its effectiveness in pest control it is a good farming practice and can usually be accomplished with very little added expense. Rotary tillage tools and soil chopping machines are being tested to determine their effectiveness in the control of various insects, such as Japanese beetle larvae and white grubs found in the soil.

11 To control some pests the plant remnants after harvest may be destroyed or treated in such manner as to destroy the pest for which this material is host. For control of European corn borer, the husker-shredder and ensilage cutter if used carefully kill practically all borers in the plants. Corn pickers have also been developed which cut or shred the stalks at the time the corn is picked. To get borers left in standing stalks in field after corn is picked, shavers and rakes have been developed for cutting and gathering this material into windrows for burning. These same methods are being used for control of pink bollworm in cotton. Gin trash from the cotton is treated by grinding or by burning to kill the contained worms.

12 To develop economical methods of mixing poison with soil for grub control. Attention has been given to this in experiments to control the Japanese beetle.

From information furnished by men who are working on pest control problems, it is certain that agricultural engineers can give a great deal of assistance along all of these lines.

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[1]Preliminary report for the Committee on Insect Pest and Plant Disease Control (R. M. Merrill, chairman) of the American Society of Agricultural Engineers, presented at a meeting of the Power and Machinery Division, at Chicago, December 1933.

[2]Agricultural engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture. Mem. A.S.A.E.

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RAYMOND OLNEY, Editor

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Research More Needed Now Than Ever

THE QUESTION is being asked in many quarters why research is needed in the industries when overproduction in some lines and the generally prevailing subnormal buying power have all but paralyzed the industries, including the agricultural industry. The program of agricultural research especially has come under fire, apparently with the unfortunate and inaccurate thought in the minds of many that the sole purpose of research is to increase production.

History shows that emergencies such as the present occur from time to time and invariably result in readjustments in many human affairs, particularly those of an industrial character. History also shows that some industries survive such emergencies and others do not. There is a lot of evidence to indicate that those industries which have available the knowledge and foresight to permit them to intelligently readjust their affairs quickly and with a minimum of expense, lost motion, and lost energy, are usually those which survive such emergencies and eventually thrive again.

This appears to be one of the main justifications for the entry of research into industry. Where readjustments of both a social and scientific character are necessary, as in the present agricultural emergency, research is ready to point the way. The results of research provide both the inspiration and the basis for wise and efficient readjustments, and in that respect agriculture is no different from any other industry.

Director P. S. Burgess of the Arizona Agricultural Experiment Station, in the 44th annual report of his station, draws some interesting and pointed parallels in connection with the function of research as a guide to intelligent readjustment of agricultural and other industries during normal times as well as during emergencies. Director Burgess in answering the question as to why the research program in agriculture should continue at this time states:

Considerable sums are spent by our federal and state governments for research in the field of agriculture, mining, forestry, education, commerce, highway engineering, and the like, but the amounts of government money appropriated for research are relatively small when compared with the enormous sums spent by our great manufacturing and distributing industries. Every major industry in the United States today is founded upon the results of research largely carried on during the past two or three decades. Every electrical appliance is the result of research; in fact, almost everything that we use, from the telephone to the can opener, is applied research. The talking movies, the radio, the automobile, the airplane, the thermos bottle, farm machinery, and dozens of other indispensable articles of everyday life fall into this category.

The United States Steel Corporation has 167 laboratories and employs over 2,000 research men. A summary just published by the American Railway Association lists some 3,000 distinct problems that have been studied by their research units. Some of these have saved the roads millions of dollars. One road, for example, saved over one million dollars annually by a process of chemically treating water to prevent boiler corrosion. A recent test on air brakes which occupied eight years of research and cost about two millions dollars, saves this amount and more annually. That such expenditures pay returns to the roads is shown by a pledge adopted a few months ago at a meeting of railway executives which reads, "We shall continue to utilize our organizations in the field of research and experimentation even more extensively than we have in the past," and this in spite of the most severe financial strain which the railroads of this country have ever faced.

The chemical industries have largely been founded on the results of research. A survey was recently completed by the National Research Council of sixty of our largest chemical-manufacturing companies including such concerns as Atlas Powder, Du Pont, Eastman Kodak, Mathieson Alkali, Union Carbide and Carbon, Air Reduction, Armour Fertilizer, and many others. Each of them spends over $200,000 annually for research, and many spend several millions.

What is true for our chemical concerns and the steel and transportation companies is true also for practically all of our great industries. All are emphasizing their research programs in developing new products, improving the quality of old products, and reducing costs.

The world is now going through a transition stage. We are beginning a period of readjustment after having passed through the greatest business depression in history. During normal times, conditions change slowly, but during periods of stress, business is quickly revolutionized and only the fittest survive. Contrary to general belief, more progress is made in efficiency during one year of depression than during five years of great business activity. The firm or the farmer that emerges from one of these adjustment periods with more efficient and more economical methods, and with new and better products, will be the one most likely to succeed in the next era of prosperity which is sure to come. Preparation for future success takes the form of original research carried on assiduously during periods of stress. Changes are probably not quite so abrupt in farming as in other lines of business, but the final results are similar. The farmer of the future cannot operate his farm as he did ten years ago any more than can the railroad official manage his road as he did in past years. . . . . With the farmer, if nation-wide underconsumption changes his profits into losses, he must learn to raise crops cheaper, or of better quality than his neighbor, if he expects to remain in the farming business.

There are two well-recognized types of research: *fundamental* and *applied*. Fundamental or theoretical research has for its object the furtherance of human knowledge without regard to its immediate application. The results of such research are the tools which the applied research worker uses in constructing the things of value. Thus, both kinds of research are necessary. It is interesting to note that many of our best known inventions, such as the radio, the telephone, the aeroplane, radium, X-rays, the thermos bottle, and anaesthetics, are all the direct result of fundamental research. Not a single one of these was the result of a deliberate intention on the part of the inventor to make money or to improve living conditions, and yet the general public entirely fails to appreciate the value of fundamental research. Without it there could be no applied research. Most of our agricultural research is *applied*, but it is directly based on the fundamental researches of the chemist, the physicist, the geneticist, the botanist, and the zoologist.

The American farmer uses machinery, commercial fertilizers, highly pedigreed plants and animals, and modern methods of management, all of which are the direct result of scientific research. Without this new information which research has applied, our farmers would still be operating as do Indian farmers today, or as did our own farmers in Colonial times.

Even in this unprecedented depression, with low prices and heavy financial burdens, most of our farmers and ranchers are still riding in automobiles, many of them have radios, and none are starving to death or suffering from uncontrolled disease epidemics. The hardest manual labor, both in the field and in the home, is

often made easier with modern farm machinery and with electrical appliances. Our farmers read the daily papers, magazines, and books, and enjoy many amusements absolutely unknown in the more backward countries. They raise high-yielding crops and pedigreed animals, thanks to the plant and animal breeders, and use commercial fertilizers and insect-killing sprays where necessary to increase production and produce a quality product. All has been made possible through research work, done almost entirely by our agricultural experiment stations and by the U. S. Department of Agriculture. There are many things which the farmer can do for himself, but there are equally as many things which he cannot do. He must use the results of scientific experimentation more and more if he is to continue to maintain his high standards of living and, at the same time, successfully compete with the low-priced labor of other countries when marketing his surpluses.

Problems originate on the farm but must be solved in the laboratory or under controlled greenhouse or field conditions. If the farmer will observe, and if the scientist will explain, surely such a partnership will produce results. The scientist should find out the "reasons why"; then the intelligent farmer can work out his own economic salvation. It is in times of stress like the present that the results of research are especially needed. To succeed, farmers and ranchers must raise quality products cheaper than their competitors, and we must all learn more about the economics of present-day social relationships. Only research of a high order can solve these problems.

The philosophy of industrial research in general, as expressed by Director Burgess, seems to apply with special force at this time to the research in agricultural engineering. The necessity for adjustment and readjustment to meet the rapidly changing economic and social conditions in agriculture is becoming daily more apparent. The rational development and use of machinery to meet the requirements of adjusted cropping practices economically is one of the most important fields in which the agricultural engineer may develop his research tendencies at this time. The great program of adjusted and controlled land use is one in which the special training of the engineer is particularly valuable at this time, provided he exercises such foresight and judgment as will contribute to the economic utility of all lands. There is no end to the service which the research agricultural engineer can render at this time, but his efforts must be guided by that engineering judgment which in the early days characterized the engineer as the man who can do with one dollar what the ordinary man can do with two.

The signs of the times are social betterment and greater economic stability for all, and to accomplish this in agriculture the producer of agricultural commodities must be prepared to compete fairly but effectively with others without the necessity of resorting to destructive practices. In this connection the engineer becomes more than simply a manipulator of physics, mechanics, hydraulics, and electricity. He must in truth become an adjuster of the forces of nature to the benefit of mankind.

NEWS

A.S.A.E. Annual Meeting Program

AT A MEETING called recently by Chairman L. J. Fletcher of Meetings Committee of the American Society of Agricultural Engineers, it was decided that the 1934 annual meeting of the Society—in case it is held at Detroit instead of on the Great Lakes—would be confined to three days this year. The dates of the meeting as previously determined by the Council will be during the week of June 18.

It is planned to devote the forenoon of the first day to concurrent sessions of the College Division, the Student Agricultural Engineers' Conference, and the Committee on Extension. The afternoon will be given over to concurrent sessions of the Land Reclamation Division and the Rural Electric Division, both of which groups may continue their programs into the evening of the same day, if they so desire. The evening will be available also for other groups and committee meetings.

It is planned to devote the entire second day of the meeting to a general symposium on the subject "The Engineering Phases of Land Use Planning." In addition to a few prepared discussions covering specific phases of the subject, there will be plenty of opportunity for discussions from the floor, and also for contributions from the four main technical groups of the Society.

The forenoon of the third day of the meeting will be devoted to concurrent sessions of the Power and Machinery Division and the Farm Structures Division, and the afternoon will be turned over to the four technical divisions for concurrent sessions.

If there are any technical division groups or committees that do not find sufficient time to schedule their meetings within this three-day period, they will be encouraged to extend their sessions to the evening of the third day, or the following day.

It is also the thought of the Meetings Committee that the day following the three-day meeting will be available for such inspection and sightseeing trips as may be planned for the occasion.

If a sufficient number of reservations are secured to make the combined meeting and boat trip possible, the time and arrangement of the foregoing outline will be changed to conform to the boat schedule.

Restored

It will be of interest to agricultural engineers to learn that, in the hearings recently before the House of Representatives subcommittee of the Committee of Appropriations dealing with the agricultural appropriation bill, the provision for the Division of Irrigation in the U.S.D.A. Bureau of Agricultural Engineering, previously omitted by the Bureau of the Budget, was restored to the bill.

Personals

J. T. McAlister, formerly extension agricultural engineer at Clemson College in South Carolina, is now chief agricultural engineer on the South Tyger River Erosion Control Project, one of the ten regional projects set up by the Soil Erosion Service of the U. S. Department of the Interior. His address is Box 267, Spartansburg, S. C.

H. P. Smith, chief, agricultural engineering section, Texas Agricultural Experiment Station, is one of the authors of Bulletin No. 486, entitled "New Developments in Hog Houses and Equipment," recently issued by that institution.

New ASAE Members

H. W. Gerlach, superintendent, flood and erosion district, Wauzeka, Wis.

G. B. Hanson, engineer, Wisconsin Conservation Commission, State Capitol, Madison. (Mail) 515 North Henry St.

Arthur C. Jacquot, instructor, agricultural engineering department, Washington State College, Pullman, Wash.

Willard L. McFillan, engineering foreman, U. S. Forest Service, Camp Kenney, Kalvesta, Kans.

Earl C. Rieger, assistant to chief engineer, gas power laboratory, International Harvester Company, 2626 W. 31st Blvd., Chicago, Ill.

Applicants for Membership

Frank F. Alexander, sales manager, Electric Wheel Company, Quincy, Ill.

Wm. Leverett Cummings, sales promotion division, Frigidaire Corporation. (Mail) 40 Jane Road, Newton Center, Mass.

Clarence E. Ghormley, senior engineer, Wisconsin Industrial Commission, Bangor, Wis.

Linwood D. McClure, supervisor of retail and rural sales, Philadelphia Electric Company. (Mail) York Road and Summit Ave., Jenkintown, Pa.

William F. Simpson, foreman engineer, Kentucky State Forest Service, CCC Camp No. 63-P.E., Hardinsburg, Ky. (Mail) RFD No. 1, Smithfield, Ky.

Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, senior agricultural engineer, Office of Experiment Stations, U. S. Department of Agriculture.

CHART DETERMINES HAULING COSTS AND NUMBER OF TRUCKS REQUIRED, *R. D. Gladding*. Engin. News-Rec., 111 (1933), No. 7, p. 199, fig. 1. A brief mathematical analysis of truck hauling is presented, together with a diagram for determining cost of haul.

LEAKY BRICK WALLS AND HOW TO PREVENT THEM, *J. H. Mallon*. Architect. Rec., 72 (1932), No. 6, pp. 412-416, 32, 34, figs. 4. Experiments with eight different kinds of brick and six different mortars built into small reservoirs to test watertightness are reported.

It was found that water does not soak through the brick or through the mortar, but enters through openings and cracks between the brick and mortar where a close bond does not exist. No particular type of mortar caused leaky walls. In every case all mortars gave identical results when used with the same brick.

The conclusion is drawn that the most frequent cause of leaky walls is poor workmanship, resulting in insufficient mortar in the wall, especially in the head joints. The importance also is emphasized of designing a structure so that water will not concentrate against any part of the wall. One of the best precautions is to select the proper type of mortar joint. A tooled finish, preferably concave or V-shaped, is strongly recommended.

It also seems desirable to avoid extremes of high or low absorptive power in the brick. Mortar should be plastic, so it will spread out evenly, permitting a more complete bedding of the brick and an increased area of contact between the surface of the brick and the mortar, and so that the longitudinal joints which parallel the face of the wall will be completely filled when mortar is slushed into them.

AGRICULTURAL ENGINEERING INVESTIGATIONS AT THE TEXAS STATION, *R. E. Dickson, D. Scoates, B. C. Langley, H. P. Smith, D. T. Killough, D. L. Jones, B. H. Hendrickson, R. W. Baird, H. V. Gieb,* and *H. O. Hill*. Texas Sta. Rpt. 1932, pp. 51, 102-104, 124-129, 151-154, 164-166. The progress results of investigations on run-off water losses in relation to crop production, mechanical harvesting of cotton, factors of efficiency in the distribution and placement of cottonseed and fertilizer, soil erosion, and moisture conservation are briefly reported. The studies on soil erosion and soil moisture conservation are being conducted in cooperation with the U.S.D.A. Bureaus of Agricultural Engineering and Chemistry and Soils and the investigations on placement of cottonseed and fertilizer in cooperation with the Bureau of Agricultural Engineering.

NOTES ON THE SPONTANEOUS COMBUSTION OR IGNITION OF HAY, *F. R. Dodd*. Analyst, 58 (1933), No. 683, pp. 77-80. This paper relates briefly the author's experience in determining the cause of hay fires with particular reference to the detection of spontaneous combustion. Some data from hay tests of this character are briefly presented.

VENTILATION OF POULTRY HOUSES FOR LAYING AND BREEDING HENS, *J. C. Huttar, F. L. Fairbanks,* and *H. E. Botsford*. New York Cornell Sta. Bul. 558 (1933), pp. 48, figs. 33. The results of studies conducted during the 6-year period from 1925 to 1931 on poultry house ventilation are presented, together with a review of data from other sources.

Two 20x20 ft pens were used in the studies, these being constructed as one long building with an 8x20-ft observation and feed room between them. One pen was constructed according to the regular plans of the Cornell laying house, whereas the other differed in that it was insulated inside with Celotex, the center curtain openings were fitted with windows, and a Rutherford type ventilation system was installed. While egg production was good in both pens, it was much larger in the insulated pen. The 6 years' average figures for the two pens showed no significant different in the quantity of feed required to produce one dozen eggs.

Relative humidity, ranging from 40 to 95 per cent but never remaining above 90 per cent longer than 24 h, seemed to have no effect on pen conditions or on the activity of the birds throughout this test. While health and mortality conditions were not so desirable as might be expected, there was no significant difference in these conditions between the two pens. Practically no difference was found in the hatchability of the eggs from the two pens except for the first year, when the more open pen gave the best results.

For winter conditions as found in central New York, the litter does not become damp if not more than 150 birds are placed in a pen of similar construction to that of either pen in this experiment, provided the ventilation is also similar. More than 150 birds in a 20x20-ft pen seemed to cause damp litter in the winter. Neither pen was excessively drafty when the front was open unless a very strong wind was blowing from a southerly direction. The rate of air movement through either pen, when closed on cold days, was strongly influenced by the rate of air movement outdoors and the direction of the wind. A south wind induced the most rapid air movement through the pen. There seems to be little or no relation between the difference in temperature between indoors and out and the rate of air movement through the pen, for differences not exceeding 18-deg F.

The data obtained in this test indicate that the regular Cornell laying house is satisfactory for central New York conditions to house South Carolina White Leghorn pullets. While the insulated pen with the commercial ventilation system gave as good or very slightly better results than the regular Cornell house, the difference was not sufficient to warrant the added expense of insulation and the installation of the ventilation system used.

The curtains in the front of the Cornell laying house should be closed when the temperature drops below 15 deg outdoors or whenever a strong wind or storm is blowing in. The front rafter ventilator should be constructed so that there is a 1-in opening along the entire length of the house when the door is closed. This is to permit the air to flow out of the house at all times and to prevent the wind and storm from blowing into the house. This front-rafter-ventilator door may be left open at all times except when strong winds are blowing against the front of the house, or, if the operator desires, at temperatures below 15 deg.

A PRELIMINARY SURVEY OF THE USE OF ALCOHOL AS MOTOR FUEL IN VARIOUS COUNTRIES. Ames: Iowa State Col., 1932, pp. [2]+4. Data are summarized for the United States and 17 other countries including the Philippine Islands.

KNOCK RATING TESTS OF ALCOHOL-GASOLINE MIXTURES. Ames: Iowa State Col., 1932, pp. [1]+3. Tests to determine the octane number of each of three mixtures of alcohol and gasoline are reported. These included base fuel 90 per cent plus alcohol 10 per cent; base fuel 84 per cent plus alcohol 15 per cent, and acetone 1 per cent, and base fuel 80 per cent plus alcohol 20 per cent.

The increases in octane number of the mixtures over 100 per cent gasoline were 9, 12, and 24 points, respectively. The use of 20 per cent of alcohol produced a mixture considerably higher in octane value than commercial ethyl gasoline.

ABSTRACTS OF THE MORE IMPORTANT TECHNICAL PUBLICATIONS CONCERNING THE USE OF ABSOLUTE ALCOHOL IN GASOLINE AS A MOTOR FUEL. Ames: Iowa State Col., 1933, pp. [2]+40, pls. 2. This is an extensive analytical review of the literature on the subject.

ROAD TESTS ON ALCOHOL-GASOLINE MIXTURES. Ames: Iowa State Col., 1933, pp. 11. The results are briefly presented of (1) mileage and acceleration tests on eleven cars of different size and weight, (2) mileage and acceleration tests on a specially equipped test car, and (3) mileage and power tests on a test car equipped with a gas-electric drive.

It was found that the use of a blend of 10 per cent alcohol and 90 per cent gasoline results in a fuel mileage as good as that obtained with straight gasoline. At speeds of 10 and 20 mph a 4 per cent increase in mileage is evident when the blended fuel is used. At the higher speeds of 40 and 50 mph this advantage disappears and equal mileages are obtained with both fuels. Improved acceleration and better performance are noted with the use of the blended fuel. Again the tests show that these increases in acceleration are greatest at the lower speeds. The conclusions indicate the following advantages for alcohol-gasoline mixtures: (1) Smoother operation, especially at idling speeds, (2) elimination of any knocking present when ordinary gasoline is used. *(Continued on page 114)*

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Agricultural Engineering Digest

(Continued from page 112)

The speed at which a car is driven has more effect on fuel consumption than any other item. On the average, a 10-mile decrease in speed is accompanied by a 10 per cent increase in fuel mileage. It must be apparent, therefore, that comparable results from tests on both types of fuels can be obtained only when the same speed is maintained. Comparing the two fuels, it is apparent that the blended fuel has a slight advantage over regular gasoline. Both fuels are burned with the same ease, equal mileages are obtained in each case, but increased performance is noted when the blended fuel is used.

CARBON DEPOSITS IN GASOLINE ENGINES, *W. A. Gruse.* In Symposium on Motor Lubricants. Philadelphia: Amer. Soc. Testing Materials, 1933, pp. 7-21, figs. 4. This paper presents a review of available data on the formation of so-called carbon deposits in gasoline engines. The various factors influencing the rate and amount of deposit also are discussed and, where possible, actual experimental results are cited to show the magnitude of the effects described. Particular attention is given to the influence of lubricating oil on deposits, and a critical discussion is offered covering the several tests of lubricating oils proposed for the prediction of carbon-depositing tendency. The modification of engines to permit using highly refined oils of low viscosity is indicated as desirable.

It is indicated that if an engine without an air-cleaner runs cool on a rich air-fuel mixture with a high oil consumption, the oil being one of high carbon residue value, the engine will very probably encounter a great deal of trouble traceable to carbon deposits. The opposite conditions, dust-free air, a hot-running engine with a lean air-fuel mixture, and low consumption of an oil of low carbon residue value, will very probably induce freedom from excessive deposits. As regards the lubricating oil itself, the study suggests the desirability of hastening the day when the average motor can use, with tolerably low consumption, oils of lower viscosity than the present S.A.E. 40 and 50 grades.

PRESENT CONCEPTS OF THE RELATION OF A.S.T.M. POUR TEST TO SERVICE REQUIREMENTS OF OILS, *J. L. McCloud.* In Symposium on Motor Lubricants. Philadelphia: Amer. Soc. Testing Materials, 1933, pp. 27-37, figs. 2. This is a critical analysis of the findings of others from which the observation is drawn that the A.S.T.M. pour test is one of suitability, and that in any general type of oils it or some related test must be used in consideration of the service requirements of oils for internal-combustion motors.

SERVICE CHANGES IN CRANKCASE LUBRICATING OILS, *M. A. Dietrich.* In Symposium on Motor Lubricants. Philadelphia: Amer. Soc. Testing Materials, 1933, pp. 57-76, figs. 11. The experimental data summarized in this contribution from Ohio State University indicate that used crankcase oils generally show a marked decrease in viscosity, flash, and fire points, and pour point because of dilution. A decided increase is noted in the carbon residue and ease of emulsification with water. The extent of change which these characteristics undergo bears no relation to the original characteristics of the oil. The presence of dilution appears to reduce the slope of the viscosity-temperature curves for those oils whose viscosity-temperature curves are steep.

The diluent consists of high boiling material possessing a considerable degree of unsaturation. Sludge formed in the oils consists mainly of carbonaceous material formed by cracking or partial combustion of either the lubricating oil or the fuel. The quantity of sludge formed cannot be related to the oxidation resistance or carbon residue of the oil but bears some relation to oil consumption. The quantity of ash-forming constituents is determined by the viscosity of the oil at the time of service, the length of service, and the characteristics of the engine. In Diesel engines the sulfur content of the sludge is fairly high and varies with the sulfur content of the fuel oil.

The distillation curves of oils used with normal quantities of make-up oil are not greatly different from those for the new oils unless the oils have a wide boiling range. The acidity of oils in use approaches a constant value which differs under varying conditions of service. A considerable portion of the acidity is volatile with the diluent and the quantity can be controlled by engine accessories. The iodine numbers of oils decrease slightly in service, but oils of high iodine numbers show no greater decrease than oils of low iodine numbers.

Oil volatility and viscosity at the time of service are the only characteristics which bear a relation to changes in service.

It is concluded that changes in characteristics of crankcase oils during service are dependent far more on the type of engine, its condition, and its manner of operation than upon the characteristics of the new oils as determined at present in the laboratory. The volatility of the oil, as measured by the spread in the distillation range and the viscosity in so far as it is affected by dilution at the time of service are the only characteristics which appear to have some quantitative relationship to the changes which the oils undergo.

STABILITY OF STRAIGHT CONCRETE GRAVITY DAMS, *D. C. Henny.* Amer. Soc. Civ. Engin. Proc., 59 (1933), No. 7, pp. 1071-1091, figs. 8. The necessity for abandoning the middle-third theory and the sliding factor as useful elements in masonry dam design is demonstrated in this paper. The author develops the fact that the safety of straight masonry dams is principally due to shear, and he investigates the effect of loading on shearing strength. A resume is given of available data on uplift pressure, and estimates of effective uplift area and of uplift force are presented. Stability of dams of ideal triangular cross section is studied and a shear safety factor is proposed for use in dam design.

The Levy requirement that loading at the water face must not be less than the water pressure at that elevation is found to be excessive for dams less than 500 ft in height under most adverse condition of uplift, and more logical requirements fitting these conditions are suggested. Numerical examples are given of shear safety factors on the basis of cross sections of existing dams. It is shown that the principles developed for straight concrete dams can be made equally applicable to other types of masonry dams.

THERMAL INSULATION, *E. Griffiths.* Jour. Rol. Soc. Arts, 81 (1933), No. 4214, pp. 911-926, figs. 2. A survey of methods of insulating refrigerating and cold storage equipment is presented.

THE STRAW-LOFT POULTRY HOUSE, *E. G. Johnson* and *H. H. Alp.* Illinois Sta. Circ. 412 (1933), folder, figs. 6. Practical information on construction is given together with working drawings and a bill of materials for a 20x20-ft house.

RAMMED EARTH WALLS FOR FARM BUILDINGS, *R. L. Patty* and *L. W. Minium.* South Dakota Sta. Bul. 277 (1933), pp. 67, figs. 40. Studies are reported the purpose of which was to learn the characteristics of soils favorable to rammed earth construction and to determine the optimum clay and sand ratio and the optimum moisture content for both strength and weathering resistance in rammed earth walls. Studies also were made on protective coverings, on the effect of adding fiber to the dirt, on rammers and the proper ramming of dirt into the forms, on reinforcing for wall openings and corners, and on the best practices in building walls of this material. Finally a study of the cost and economy of rammed earth walls and their relative insulated value in the control of frost deposit when used for housing livestock was conducted.

The strength tests in compression were made to determine the relative value of certain soil characteristics for building practices. Samples of soils from all parts of South Dakota were analyzed and tested both for strength and for resistance to weathering. These soils were taken from eighteen counties of the state covering the extreme territories. All test blocks were cubical in shape and were 9 by 9 by approximately 9 in. They were about as heavy as can be conveniently handled, weighing from 45 to 60 lb when first made, depending upon the amount of sand in the dirt. They were rammed in forms with hand rammers and handled on board trays 12 in square. The test beams for the reinforcing study were 36 by 12 by approximately 7.75 in in depth. They weighed from 250 to 260 lb and were handled on slat trays approximately 10 by 48 in.

It was found that rammed earth walls are an excellent insulating material, making an exceedingly warm wall in cold weather and a cool wall in hot summer. Rammed earth construction lends itself well to the construction of simple buildings with few wall openings.

The speed of construction should average approximately 2 cu-ft of wall per man-hour after experience is gained in handling and moving the forms. Mechanical rammers driven by compressed air may average 7 cu ft of wall per hour.

The best sand content in the soil used was found to range between 30 and 70 per cent, although there are soils outside this range that are quite satisfactory. The sandy soils resist shrinking and checking, ram more easily, require less moisture, and generally weather better. Rammed earth construction can be carried on in a season when moderate freezing weather may be expected, but it is not a desirable practice. Screening the dirt for rammed earth work is not usually necessary. Deep concrete foundations are unnecessary for low rammed earth walls, although the foundation should be strong, as wide as the wall, and extend at least 12 in above the ground. Some coarse aggregate seems desirable in the dirt used and in sizes up to 2 in, but this gravel should be well graduated and not all of the same size. Fibrous materials such as grass, fine roots, and straw increase the strength *(Continued on page 116)*

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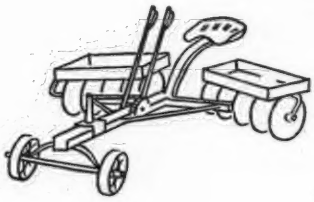

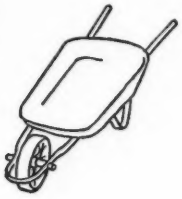

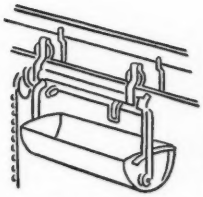

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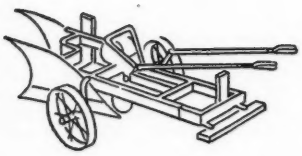

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(Continued from page 114)

of rammed earth in compression, but they are unnecessary for low walls at least and interfere with the painting of the surface.

Protective coverings are highly desirable if not absolutely necessary for a rammed earth wall. The wall should last as long as the covering is kept in repair and such a wall is superior to others in many ways. Adding hydrated lime to the soil reduced the strength materially and made the wall crumbly. Steel reinforcing rods were found to be the best reinforcing material tried in rammed earth construction.

Ordinary house paint is possibly the most practical covering for rammed earth walls. The best time to apply the first coat is during construction and about 5 days after the forms are removed from the section to be painted. The priming coat may be of raw linseed oil or an ordinary priming coat of paint. Plaster or stucco makes a good substantial covering but should not be applied until the wall has gone through the shrinking period. This will take at least 10 days after the wall is rammed and if the weather is dry.

A comparison of temperature records in a rammed earth house with other similar poultry houses during the month of February 1933 (which was an exceptionally cold month) showed it to be 3.45 deg F warmer in the earth house in early morning. At 1:00 p.m. the frame house averaged 2.11 deg warmer than the earth house. This made the fluctuation of temperatures in the earth house less than in the frame house by 5.56 deg during the day.

ELECTRICALLY HEATED GARDEN FRAMES, *E. A. Beavis.* Rural Electrif. and Electro-Farming, 9 (1933), No. 99, pp. 82-85, figs. 6. Brief information is given regarding a small inexpensive installation for the amateur gardener.

FUNDAMENTAL PRINCIPLES OF SOIL COMPACTION, *R. R. Proctor.* Engin. News-Rec., 111 (1933), No. 9, pp. 245-248, figs. 3. This is the first of a series of four articles describing the application to the design and construction of rolled-earth dams of recently developed methods for controlling the compaction of soils.

Under the new procedure a series of simple laboratory and field tests determines the suitability of the available soils, supplies essential data for the design of the dam, serves as a basis for the control of construction operations, and furnishes a definite check on the effectiveness of the work as it proceeds.

Methods are described for compacting soils so that they will be sufficiently watertight and will not become soft and unstable if completely saturated with water.

HYDROGEN: A COMMERCIAL FUEL FOR INTERNAL COMBUSTION ENGINES AND OTHER PURPOSES, *R. A. Erren* and *W. H. Campbell.* Jour. Inst. Fuel [London], 6 (1933), No. 29, pp. 277-285, figs. 6. A brief review is given of experimental work already conducted on hydrogen as a fuel, and the absence of detonation with suitable mixtures and its value as a diluent are emphasized. Methods of working the hydrogen-air engine are discussed, the economic performance of 45 per cent brake thermal efficiency independent of load is stressed, and the performance and temperatures attained are compared with those of the gasoline engine. The oxy-hydrogen engine, using steam as the diluent, and other applications of hydrogen as a fuel are described. Attention is drawn to the use of hydrogen as a promoter of combustion when mixed with fuels such as alcohol, and also as a primer in Diesel engines.

THE EFFECT OF METALLIC (LEAD) DOPE ON THE CARBONIZATION OF OIL IN THE COMBUSTION SPACE OF AN ENGINE, *R. O. King.* Engineering [London], 136 (1933), No. 3528, pp. 183-186, figs. 7. Studies on the effect of tetraethyl lead dope on piston lubrication are reported. The dope was added to the oil as ethyl fluid containing lead tetraethyl and ethylene dibromine, 60 and 40 parts by volume, respectively. The lubricating oil was a proprietary mineral blend in general use.

The experiments on the rate of deterioration of the dope content of lubricating oil during use showed that with a normal rate of aeration about 20 per cent of the lead is driven off as vapor in from 2 to 3 h and the remaining 80 per cent remains for the following 20 h. Even with foaming aeration extending over a 22-h period, an appreciable proportion of the original quantity remained in the oil.

Journal-bearing lubrication experiment showed that at 40 deg C the oil diminished in lubricating value with use. At 100 deg the lubricating value remained nearly unchanged, while at 150 deg a remarkable improvement was exhibited. The action of ethyl fluid in preventing the formation of carbonaceous products by oxidation and a consequent increase in fluid friction was shown by the fact that friction at 40 deg remained constant within the limits of experimental error over the 70-h period of the trial.

Experiments on the effect of ethyl fluid on the oxidation of the oil used to lubricate the piston of a two-stroke, air-cooled engine resulted in superior performance which coincided with a reduction of the rate of oil consumption of 20 per cent.

Bench trials of a four-stroke engine, lubricated with plain oil and with the same oil plus 12 cc per gallon of ethyl fluid, showed that for both oils the optimum performance is reached after a running-in time of about 4 h. The first permanent lubrication failure when using plain oil occurred after the engine had run for about 2 h at the higher power output attained as a result of running-in, although the running was unstable at all times. Temporary lubrication failure occurred early in the running-in period and the effect was always imminent. When the engine was lubricated with oil plus dope, the relatively higher output reached after the running-in period was maintained with little variation for nearly 10 h, when the first lubrication failure occurred. The first lubrication failure in both trials was followed immediately by a partial recovery succeeded by a second failure, after which the engine continued to run for an indefinite period but at reduced power. A decided decrease of fuel economy and a similar increase of cylinder temperature are coincident with the first lubrication failure. The piston ring condition corresponded well with the performance of the engine. Thus the first permanent lubrication failure occurred with both oils when the condition of either ring fell below the sticking-at-one-spot state.

A CONTRIBUTION TO THE THEORY OF FILM LUBRICATION, *A. M. Robb.* Roy. Soc. [London], Proc., Ser. A. 140 (1933), No. A 842, pp. 668-694, figs. 16. This is a highly technical report on film lubrication between shaft and bearing in which it is brought out that the assumption that the length of the bearing brass determines the length of the oil film under pressure leads to an unreal conception of the velocity conditions at the inlet end of the film and to unjustifiable curves of pressure along the film, and does not give results in harmony with those of actual experiment.

When consideration is given to the character of the curves of velocity across the film, from fixed surface to moving surface, it is seen that extent of brass is not a material factor in the problem and that the extent of the film is determined by other considerations.

Comparison of the experimental results recorded by Goodman in 1928 with those recorded by him in 1932 leads to the discovery of a serious flaw in the statement of the fundamental equation of Reynolds, namely,

$$\frac{dp}{dx} = 6\lambda u \frac{h - h^1}{h^3}$$

in which p is the pressure, λ the coefficient of viscosity, x the measure in the direction of motion, u the velocity of the moving surface, and h the distance between the surfaces at any point other than that corresponding to h^1, which is the distance between the surfaces at the section where the pressure is maximum or minimum. The case of minimum pressure is, however, rejected from the immediate consideration. Accepted theory and all mathematical developments take h^1 to be the height at the section of maximum pressure and so to be a constant. h^1 is, however, a variable, and is a measure of the quantity of flow at any section. From this fact springs the necessity for dealing with the matter of side outflow of lubricant, and this in turn introduces a new conception, namely, side inflow.

On these modified conceptions it is shown that for any radial clearance the coefficient of friction is dependent upon eccentricity alone. Further, on these modified conceptions it is possible to obtain agreement between experiment and calculation, both as regards load-carrying capacity and attitude-eccentricity locus.

THERMAL INSULATION, *E. Griffiths.* Jour. Roy. Soc. Arts, 81 (1933), No. 4215, pp. 930-943, figs. 8. This is the second of these papers which deals largely with the technic and methodology for measuring thermal conductivity of various insulating materials, including furnace insulation, bricks, and soils.

EXPERIMENTAL STUDIES OF NATURAL PURIFICATION IN POLLUTED WATERS. VII. The selection of a dilution water for bacteriological examinations, *C. T. Butterfield.* Public Health Rpts. [U.S.], 48 (1933), No. 24, pp. 681-691. Studies conducted by the U. S. Public Health Service are reported in which bacteriological examinations were made of samples from seven widely separated locations in the United States, using five different dilution waters and the results compared.

It was found that phosphate dilution water and Formula C water gave the most consistent results. The phosphate water was prepared by adding 1.25 ml (milliliters) of stock phosphate buffer solution per liter of distilled water. *(Continued on page 118)*

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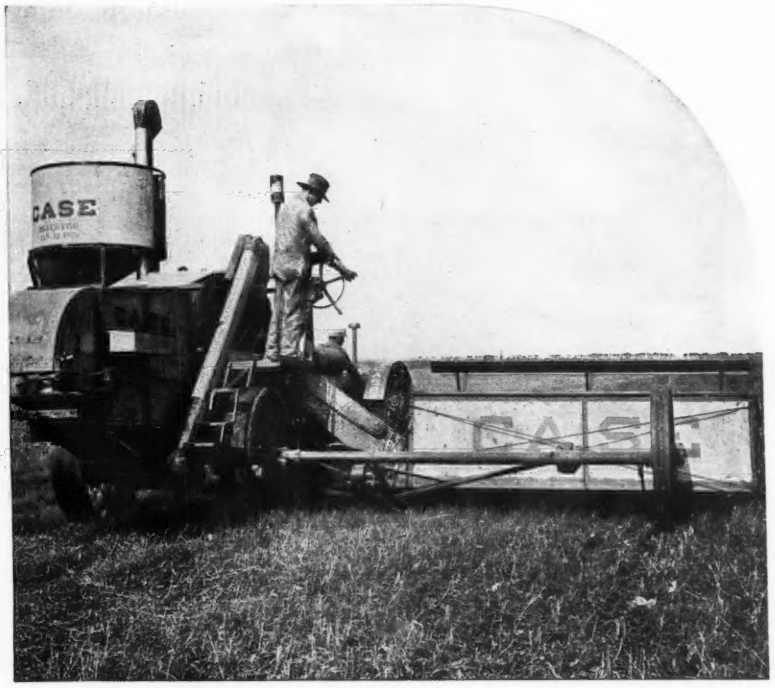

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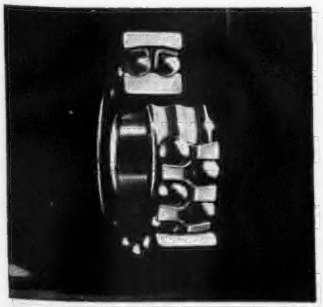

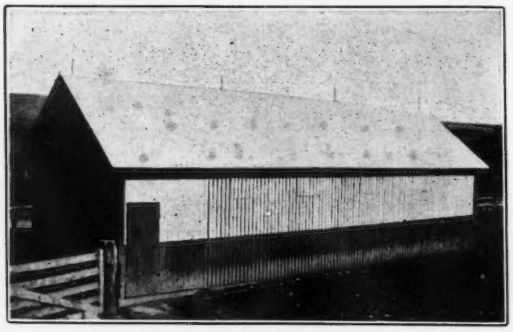

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(Continued from page 116)

Formula C water was prepared by adding to each liter of phosphate dilution water stock solutions consisting of 0.1 M calcium chloride, 2.5 ml; 0.04 M magnesium sulfate, 2.5 ml; and 0.001 M ferric chloride, 0.5 ml.

With a view to the development of a dilution water which can be used for both bacteriological and oxygen demand tests, it seemed desirable to standardize on the readily prepared phosphate water for further study, as it forms the basis for the more complete Formula C water. In the bacteriological examination of natural waters the dilution water employed must contain some mineral salts. The amount of mineral salts required in the diluting water, within the range found in natural waters, does not appear to be critical so far as the survival of the bacteria is concerned. If growth of the bacteria without lag is desired, it is probable that a degree of mineralization corresponding to that of the natural water would be more favorable.

The H-ion concentration of the dilution water also does not appear to require critical adjustment, providing it is not lower than pH 8.2, if survival of the bacteria for a short period only is desired. However, if growth of the bacteria without lag is desired, a pH of 7.5 should probably not be exceeded. Distilled water and dilution waters with H-ion concentrations in the zone of pH 9.0 or lower are decidedly bactericidal.

In making tests on the suitability of dilution waters, the examinations should be made after the water has been sterilized, for the sterilization process may very greatly alter the characteristics of the water. This is particularly true for tap and bicarbonate waters. Consideration must also be given to the glass container in which the dilution water is sterilized. Material dissolved from glass bottles of poor quality during autoclaving may make marked changes in the reaction and in the mineral salt content of the water.

ELECTRIC SOIL HEATING, 1933 STUDIES, *G. W. Kable* and *A. V. Krewatch*. [C.R.E.A.] Natl. Rural Elect. Proj., College Park, Md., Rpt. 8 (1933), pp. 16, figs. 18. The results of studies of surface heating supplemented with check tests on cinder insulation and wind effects are reported, together with the results of a new series of studies on insulation, mats, glazing materials, double glazing, ground slopes, and thermostats.

Surface heating resulted in saving as much as 40 per cent of the power used by cables placed at a depth of 6 in. On cold nights, temperatures were from 5 to 8 deg F higher with the same thermostat setting. Seeds germinated quicker, plants grew faster, were sturdy, and had larger root systems. Plants grew in contact with the heating cables without apparent injury, and the cables did not interfere with growth or harvesting except in sweet potato beds. A portable knock-down bed, consisting of a frame made of 1x12-in boards placed on the soil surface and without insulation or banking, gave good results with surface heat in freezing weather.

Complete cinder insulation saved 19 per cent of the power over shallow bank insulation and 12 per cent of the power over a bed with side insulation to a depth of 14 in below the bed soil. Double glazing reduced the power consumed from 20 to 45 per cent. Glass-substitute-covered beds used more power than single glass-covered beds. Straw mattresses saved from 24 to 42 per cent of the power on nights varying in temperature from 13 to 30 deg. Sloping ground in beds resulted in from 1 to 13 deg difference in air temperatures between upper and lower sides of the bed. Wind losses may be serious in unprotected beds. Thermostats should be set for "on" position to hold correct minimum temperatures and to save power.

GRAIN HARVESTING, *L. W. Ries*. Getreideernte. Berlin: *Paul Parey*, 1933, pp. 61, figs. [27]. This is mainly a descriptive study of grain harvesting practices and machinery in Germany, including combining and cutting, binding, stacking, and threshing. Relative cost data are included.

RURAL INSTALLATIONS. I. Importance of satisfactory wiring and protective technique. II. Improvement of tough rubber wiring systems—farm equipment. III. Protective systems—fuses and circuit breakers—leakage. IV. Application of leakage protection methods, *T. C. Gilbert*. Electrician (London), 110 (1933), Nos. 2871, pp. 730-732; 2872, pp. 792, 793; 2873, pp. 821, 822; 2874, pp. 850, 851. The problems encountered in rural electrification practice are discussed in the light of experience in the United States, Canada, and Germany.

With reference to the requirements of a suitable wiring system, it is contended that the tough rubber wiring system is the best for use in rural electrification. The use of a solid conductor insulated with vulcanized india rubber and a tough rubber outer coating is suggested.

The paper also deals with joints, branch switches, protection against dampness, and the like. With reference to protective sys-

tems, fuses are recommended with the use of two separate circuits, control of groups of lights by switch fuses, and protection of motors by circuit breakers.

A new leakage protective system used in Germany is described.

NIGHTLY COOLING OF ROOMS AFTER CUTTING OFF HEAT AND THE MINIMUM HEAT STORAGE OF WALLS [trans. title], *I. S. Cammerer.* Gsndhts. Ingen., 56 (1933), No. 7, pp. 73-75, figs. 2. The various effects of the heat storage capacity of walls are discussed, and the results of experiments are reported graphically showing the cooling of a series of common wall types.

The conclusion was drawn that the specification of a minimum heat loss through walls is unnecessary so long as the walls are of good solid construction. However, it is considered necessary to adapt the means of heating to the type of wall selected.

PROSPECTUS ON RURAL ELECTRIFICATION IN THE TENNESSEE RIVER BASIN, *G. W. Kable.* U. S. Dept. Agr., Bur. Agr. Engin., 1933, pp. 45, pls. 3. The purpose of this prospectus is to present a basis for formulating a practical program of research and development in the use of electricity on farms and in rural districts in the Tennessee River Basin.

Available data bearing upon the present and probable future development of agriculture in the basin are summarized, the progress made in the use of electricity on farms and in rural districts in the United States and other countries is outlined, the elements that must be considered in setting up a program of rural electrification in the valley are discussed, and a program of action is tentatively suggested.

The program of rural electrification for the basin includes features on policy, distribution plans, design of distribution lines, rural rates for electricity, farm and residence wiring, financing, utilization of electricity on the farm and in supplemental industries and research therein, and cooperation. Two appendixes summarize data on the use of electricity on farms in the Tennessee River Basin and on rural rates for electric power in the basin and in surrounding territory.

PLAN OF REHABILITATION FOR LITTLE RIVER DRAINAGE DISTRICT, southeastern Missouri, *L. A. Jones, W. A. Hutchins,* and *G. R. Shier.* U. S. Dept. Agr., Bur. Agr. Engin., 1933, pp. 40, map 1. The plan is outlined in detail. It recommends that no change be made in the legally fixed assessments for payments of the district's bonds and interest, but that for 1933 and subsequently, the bondholders accept as payment in full each year the amount that the lands can pay. In determining the capacity of the land to pay, it is pointed out that with from 80 to 95 per cent of the tillable land in the district farmed by tenants it is feasible to use the landlord's share as the measure of capacity to pay charges against the lands. This rental, if accurately determined, can be properly applied to all tillable land in the district, as it represents the entire rental obtained by the landlord and is the source from which his fixed charges of taxes and interest and his management and upkeep expenses must be paid.

The total capacity of the district to pay in any year, according to this method, is the cash value of one fourth of all the seed cotton produced that year, plus one-half of all the loose hay, plus one-third of all other crops, plus all pasture rentals. "Privilege rent," which is included in some of the pasture rentals, represents income from the land and therefore may properly be included in determining the capacity to pay.

A LIST OF FARM BUILDING PLANS FOR NORTH CAROLINA FARMS, *D. S. Weaver.* North Carolina Sta. Agron. Inform. Circ. 80 (1933), pp. [1]+6. This list includes plans which are available for distribution.

GASOLINE AND ALCOHOL, *G. McIntyre.* Canad. Chem. and Metall., 17 (1933), No. 9, pp. 184-187. Characteristics of gasoline and their significance relative to use in automotive engines are discussed, together with some technical aspects of the use of alcohol-gasoline blends.

It is concluded that from an engine-operating point of view, gasoline-alcohol blends are feasible, providing consideration is given to the fact that if the same economy is required for blends as for gasoline a lower performance must be expected, and conversely, if the same performance is expected a higher consumption of fuel is inevitable.

As regards the stability of blends, it may be possible to store blends of gasoline and alcohol of high alcohol concentrations in parts of the country where extremely low temperatures are not met with. If blending agents such as benzol, butyl alcohol, etc., are used, it may be possible to obtain blends which will be tolerable to cold and to water in practicable proportions.

STANDARDS YEARBOOK, 1933. U. S. Dept. Com., Bur. Standards Misc. Pub. 139 (1933), pp. V+255. This is the seventh issue of this yearbook. It contains outlines of the standardization activities and accomplishments of the Bureau of Standards and

A 20-Year Record of Farm Machine Improvements

HAVE farm machines shown marked improvement in quality during the past two decades? The statisticians of the federal government wanted to know. The farm trade was ready to be shown. The agricultural engineers wanted the improvement recorded. Even the manufacturers, who claimed they had made such progress in producing a better product, wanted to know in detail, step by step, and in black and white, what they had actually accomplished. And this is what happened:

1. Arrangements were made to have three well-known agricultural engineers make a disinterested, authoritative study of the engineering development and improvement of twenty-five representative farm machines during the past 20 years. Dr. J. B. Davidson, Iowa State College; Prof. G. W. McCuen, Ohio State University, and Prof. R. U. Blasingame, Pennsylvania State College, are the three engineers who made this study.

2. Not only did these agricultural engineers carefully examine and note the contrast between the farm machines of twenty years ago and those of today, but they also reviewed and recorded step by step the progression leading to the changes made. Also, instead of dealing merely with the machines under consideration as whole units, they examined as well the evolutionary changes in every part of the machines they studied. There was a total of 13,318 items in the 25 machines under consideration, including bolts, rivets, etc.

3. The results of the study were published in a 168-page book (8½x11 in), entitled "Report of an Inquiry into Changes in Quality Values of Farm Machines Between 1910-14 and 1932," which includes 64 full-page halftone illustrations showing graphically the changes that have taken place in the principal agricultural machines, and in their working parts.

The report is in four parts, as follows: Part I sets forth the purpose, scope, and conclusions of the inquiry. Part II is a chronological record of important changes in each of the 25 machines during the past 20 years. Part III exhaustively discusses changes in materials used in the manufacture of farm machinery. Part IV contains a direct comparison in detail —by both text and illustrations—of machines of the 1910-14 and 1932 periods.

4. The report of this inquiry was published by the American Society of Agricultural Engineers from which copies may be purchased singly or in bulk.

* * * * *

The price of the "Report of an Inquiry into Changes in Quality Values of Farm Machines Between 1910-14 and 1932," is 50 cents per copy (postpaid), on orders of one to twenty-five copies. Special prices will be quoted on orders for larger quantities. Place order direct with

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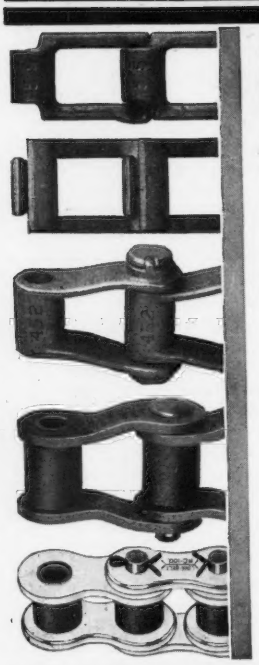

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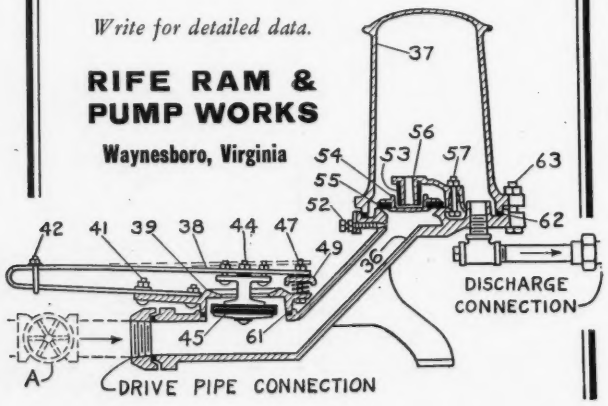

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other agencies of the federal government and of states and counties and also those of national technical societies and trade associations.

MID-WEST FARM BUILDING PLAN SERVICE. 1933, pp. 94, figs. 112. This catalogue contains descriptions of a large number of farm building and equipment plans which have been prepared cooperatively by 15 midwestern agricultural colleges. It represents a cooperative attempt by these institutions to build up a series of plans for farm buildings which are carefully designed and well detailed. The catalogue is descriptive only.

RETAINING WALL DESIGN. Pub. Works, 64 (1933), No. 8, pp. 33, 34, figs. 4. Basic elements in the design of retaining walls are presented.

MECHANICAL JOINTS FOR CAST IRON PIPE, *H. R. Cook.* Pub. Works, 64 (1933), No. 8, pp. 25-28, figs. 5. Technical information is given on the advantages of mechanical joints and on the conditions for which they are adapted. Descriptions of several types of such joints are given.

THE PIG FARM: ACCOMMODATION AND EQUIPMENT, *L. A. Downey.* Brisbane: Queensland Dept. Agr. and Stock, 1932, pp. 25, figs. 25. Practical information is given from the Australian viewpoint on hog houses and equipment, including fences, feeding and watering devices, crates, and the like.

Literature Received

BALL BEARING CATALOG. Ninth edition just issued by the New Departure Manufacturing Company, Bristol, Conn. Paper back, 5½x8½ in, 128 pp. This catalog gives complete information on dimensions, load data, and list prices of New Departure ball bearings. It contains also the new bearings types and additional sizes of existing type. Other features which make the catalog of unusual merit include the following sections: Bearing design and load characteristics, typical mounting designs, factors for the selection of bearings at electric motor speeds, factors for selecting bearings for speeds down to 10 rpm, fits and weights for all bearings, and a telegraphic code.

EMPLOYMENT BULLETIN

An employment service is conducted by the American Society of Agricultural Engineers for the special benefit of its members. Only society members in good standing are privileged to insert notices in the "Men Available" section of this bulletin, and to apply for positions advertised in the "Positions Open" section. Non-members as well as members, seeking men to fill positions, for which members of the Society would be logical candidates, are privileged to insert notices in the "Positions Open" section and to be referred to persons listed in the "Men Available" section. Notices in both the "Men Available" and "Positions Open" sections will be inserted for one month only and will thereafter be discontinued, unless additional insertions are requested. Copy for notices must be received at the headquarters of the Society not later than the 20th of the month preceding date of issue. The form of notice should be such that the initial words indicate the classification. There is no charge for this service.

Men Available

ENGINEER, with varied experience in drainage, transportation, and civil engineering problems on sugar estates, also in estimating and appraising and in making industrial surveys and cost reports, and whose experience covers a long successful record in many sections of the United States and in the tropics, is seeking a new business connection. Has been with present employer ten years but desires to make a change if he can locate in any tropical section. MA245

ELECTRICAL ENGINEER, graduate of the University of London, desires employment as rural service engineer or distribution engineer with an electric power company, or as research engineer in rural electrification with an agricultural experiment station, preferably in eastern or western United States. Several years experience in rural electrification with electric power companies and in research at a state agricultural college. Age 33. MA246.

AGRICULTURAL ENGINEER, graduate of Michigan State College, at present working for master's degree at University of Minnesota (with major in farm power and machinery), desires employment with farm equipment manufacturer either in engineering or sales work. Born and reared on a farm. In connection with college work, he has served as teaching and research assistant, all the work being in farm machinery. Available April 1, 1934. MA247